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LIFE AND WORKS OF DARWIN[1]

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I

COLUMBIA UNIVERSITY is celebrating the hundredth anniversary of the birth of Darwin, the fiftieth anniversary of the publication of the "Origin of Species." In the year 1809 many illustrious men[2] were born, among them Darwin and Lincoln, one hundred years ago to-day, February 12. So widely different in their lives, Darwin and Lincoln were yet alike in simplicity of character and of language, in love of truth, in abhorrence of slavery, and especially in unconsciousness of their power. Both were at a loss to understand their influence over other men. "I am nothing and truth is everything," once wrote Lincoln. In concluding his autobiography Darwin wrote:

> With such moderate abilities as I possess, it is truly surprising that I should have influenced to a considerable extent the belief of scientific men on some important points. My success as a man of science has been determined as far as I can judge, by complex and diversified mental qualities and conditions. Of these, the most important have been, the love of science, unbounded patience in long reflecting over any subject, industry in observing and collecting facts, a fair share of invention as well as of common sense.

Lincoln's greatest single act was his death blow to slavery. Man had been fighting for centuries for his freedom, in labor, in government, in religion, and in mind. It is certainly notable that the final victory for bodily liberty was won during the very years which wit-

[1] Address delivered at Columbia University on the one hundredth anniversary of Darwin's birth, as the first of a series of nine lectures on "Charles Darwin and His Influence on Science."

[2] Alfred Tennyson, Edgar Allen Poe, Felix Mendelssohn, Oliver Wendell Holmes, William Ewart Gladstone.

nessed the final emancipation of the mind. I do not see that Darwin's supreme service to his fellow men was his demonstration of evolution—man could have lived on quite as happily and perhaps more morally under the old notion that he was specially made in the image of his maker. Darwin's supreme service was that he won for man absolute freedom in the study of the laws of nature; he literally fulfilled the saying of St. John, "Ye shall know the truth, and the truth shall make you free."

When we look back upon the very recent years of 1858–59, the years of revolution, we see that we were far from free either to study nature or reason about it. Our intellectual chains were from the forges of theology both catholic and protestant. The Bible was read as a revelation of physical law rather than as an epic of righteousness and spiritual law. Theology while in power was itself in a most critical position, in a *cul-de-sac* of antagonism to reason and common sense, and this despite the warnings of Augustine and of Bacon. As early as the fifth century the wise theologian of Numidia had said:

> Leave questions of the earth and the sky and the other elements of this world to reasoning and observation. Perceiving that you are as far from the truth as the east from the west the man of science will scarce restrain his laughter.

Similarly, the great founder of the inductive method observed:

> Do not excite the laughter of men of science through an absurd mixture of matters human and divine. Do not commit the consummate folly of building a system of natural philosophy on the first chapter of Genesis or on the Book of Job.

It is difficult for the college student in this day of liberty, if not of license, to realize that, in the words of Lowell:

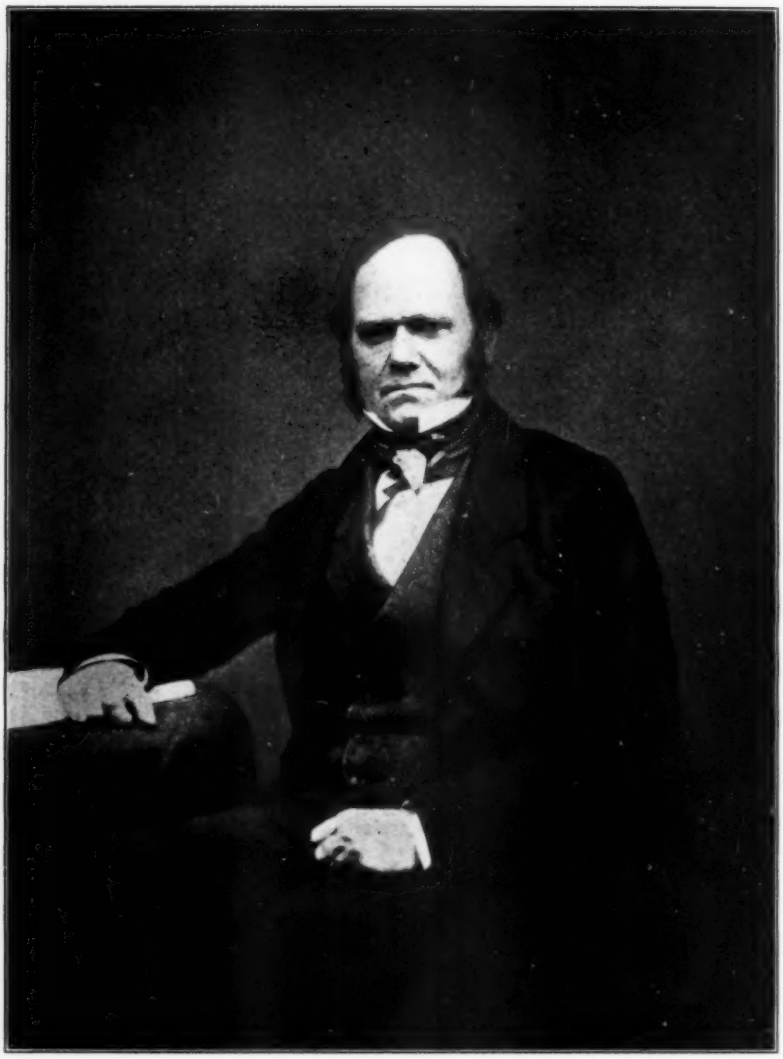
> We breathe cheaply in the common air thoughts that great hearts once broke for.

When, in 1844, Darwin communicated to the botanist Hooker under promise of secrecy his outline of evolution, he well knew the opprobrium it would bring, for he subsequently added (1846):

> When my notes are published I shall fall infinitely low in the opinion of all *sound* naturalists, so this is my prospect for the future.

From the borders of Poland in 1543, or just three centuries earlier, Copernicus had published his "Revolutions of the Heavenly Bodies," and thus fired the first shot in a three-hundred-years war for freedom to observe nature. In 1611 the telescope of Galileo demonstrated the truth of the Copernican law that the earth moves around the sun; and the most impressive object to-day in Florence is the model of the finger of this great astronomer as he held it up before the examiners of the inquisition, with the words, "It still moves."

As time advanced the prison gave way to the milder but effective



weapons of ostracism and loss of position. In biology Linnæus, Buffon, Lamarck, St. Hilaire, in turn discovered the evidences of evolution, but felt the penalty and either recanted or suffered loss of position. The cause of supernaturalism had never seemed stronger than in 1857; the masterly works of Paley and Whewell had appeared; the great series of Bridgewater Treatises to demonstrate the wisdom and goodness of God in the special creation of adaptations had just been closed; men of rare ability, Cuvier, Owen, Lyell and Agassiz, were on the side of special creation; yet at the very time this whole system of natural philosophy was rotten at the foundation because not the work of free observation.

Where his great predecessors Buffon and Lamarck had failed, Darwin won through his unparalleled genius as an observer and reasoner, through the absolutely irresistible force of the facts he had assembled and through the simplicity of his presentation. Lacking the literary graces of his grandfather, Erasmus Darwin, and the obscurity of Spencer, Darwin was understood by every one as every one could understand Lincoln. It is true the cause was immediately championed by able men, but victory was gained not by the vehement and radical Haeckel nor yet by the masterly fighter Huxley, but through the resistless power of the truth as Darwin saw it and presented it. It was not a denial, as had been the great skeptical movement of the end of the eighteenth century, but an affirmation. Darwin was not destroying but building; yet at the time good and honest men trembled as if passing through an earthquake, for in the whole history of human thought there had been no such cataclysm.

II

In what he achieved Darwin is so entirely alone that his place in the history of ideas is next to Aristotle, the great Greek biologist and philosopher who preceded him by over 2,000 years.

The biographers of Lincoln are at a loss to explain his greatness through heredity. Darwin belonged to an able family, and his ancestors are singularly prophetic of his career. He was near of kin to Francis Galton, who shares with Weismann the leadership in the study of heredity during the nineteenth century. By a happy combination of all the best traits of the best of his ancestors coupled with the no less happy omission of other traits, Darwin was a far greater man than any of his forebears. Kindliness, truthfulness and love of nature were part of his birthright. From his grandfather Erasmus, Charles may have inherited especially his vividness of imagination and his strong tendency to generalize. Countless hypotheses flitted through his mind.[3] "Without speculation there is no good and original ob-

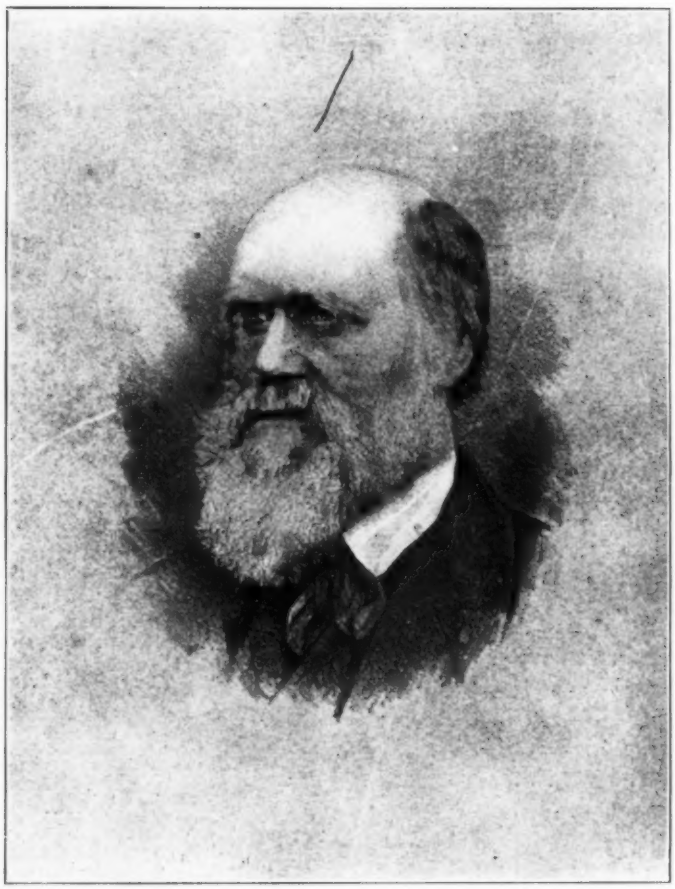
[3] "I can not resist forming one on every subject."

servation," he wrote to Wallace. Still more interesting is the fact that the inheritance of his grandfather's tendency toward speculation took the direction of evolution, for before the close of the eighteenth century Erasmus Darwin gave the world in poetical form his belief in a complete evolutionary system as well as the first clear exposition of what is now known as the Lamarckian hypothesis. But in the grandson hypotheses were constantly held in check by the determination to put each to the severe test of observation. Darwin speaks of his father, Robert, as the most acute observer he ever saw, and attributes to him his intense desire to understand the reasons of things; from him came caution and conservatism. He says in his "Autobiography":

> I have steadily endeavored to keep my mind free so as to give up any hypothesis (however much beloved), and I can not resist forming one on every subject, as soon as facts are shown to be opposed to it.

If the "poet is born not made," the man of science is surely both born and made. Rare as was Darwin's genius, it was not more rare than the wonderful succession of outward events which shaped his life. It is true that Darwin believed with his cousin Francis Galton that education and environment produce only a small effect upon the mind of any one, but Darwin underestimated the force of his educational advantages just as he underestimated his own powers, and this because he thought only of his book and classroom life at school, at Edinburgh and at Cambridge, and not of his broader life. It was true in 1817, as to-day, that few teachers teach and few educators educate. It is true that those were the dull days of classical and mathematical drill. Yet look at the roster of Cambridge and see the men it produced. From Darwin's regular college work he may have gained but little, yet he was all the while enjoying an exceptional training. Step by step he was made a strong man by a mental guidance which is without parallel, by the precepts and example of his father, for whom he held the greatest reverence, by his reading of the poetry of Shakespeare, Wordsworth, Coleridge and Milton, and the scientific prose of Paley, Herschel and Humboldt, by the subtle scholarly influences of old Cambridge, by the scientific inspiration and advice of Henslow, by the masterful inductive influence of the geologist Lyell, and by the great nature panorama of the voyage of the *Beagle*.

The college mates of Darwin saw more truly than he himself what the old university was doing for him. Professor Poulton of Oxford, believes that the kind of life which so favored Darwin's mind has largely disappeared in English universities, especially under the sharp system of competitive examinations; yet this is still more truly the atmosphere of old Cambridge to-day than of any of our American colleges. It would be an interesting subject to debate whether we



could nurture such a man; whether a Darwin, were he entered at a Columbia, a Harvard, a Princeton, could develop mentally as Charles Darwin did at Cambridge in 1817. I believe that conditions for the favorable nurture of such a mind are not with us. They are, repose, time for continuous thought, respect for the man of brains and of individuality and of such peculiar tastes as Darwin displayed in his avidity for collecting beetles, freedom from mental convention, general sympathy for nature, and above all ardor in the world of ideas. If the genial mind can not find the kindred mind it can not develop. Many American school and college men are laughed out of the finest promptings of their natures. In short I believe our intellectual environment would be distinctly against a young Darwin to-day.

Thus event after event in Darwin's life was singularly propitious. None but a Darwin would have reflected these events as he did, but grand and rare they certainly were.

At the age of nineteen he entered Christ's of Cambridge, the small college which two hundred years before had sheltered John Milton, the great poet of "Paradise Lost," the epic of the special creation theory which it was Darwin's destiny to destroy. His passion for sport, shooting, hunting, cross country riding, his genial enjoyment of friends of his own age, did not prevent delightful excursions with older men. He was known as "the man who walks with Henslow"; and close personal intercourse with this learned and genial botanist (Rev. Wm. C. Henslow) affected him more than any other feature of his college life. After graduation this personal association extended through Henslow to the geologist Sedgwick, who prepared him for the next step in his career. It was Henslow who secured for him his place on the exploring ship *Beagle* and the voyage round the world (1831–1836), by far the most important experience in his life.

No graduate course in any university can compare for a moment with the glorious vision which passed before young Darwin on the *Beagle,* but here again fortune smiled upon him, for this vision required the very scientific spirit and point of view which came to him through the reading of the "Principles of Geology" of Lyell, the masterly teacher of the uniformitarian doctrine of Hutton. That nature worked slowly in past as in present time, and that the interpretation of the past is through observation of the present gave the note of Darwin's larger and more original interpretation, because the slow evolution which Lyell piously restricted to geology and the surface of the earth Darwin extended to biology and all living beings. If during the voyage Lyell's arguments convinced Darwin of the permanence of species, Lyell's way of looking at nature also gave him the means of seeing that species are not permanent. In his own words, he "saw through Lyell's eyes," and with the admiration of others

always so characteristic of him his tribute to Lyell is without reserve. The second edition is dedicated:

> With grateful pleasure as an acknowledgment that the chief part of whatever scientific merit this Journal and the other works of the author may possess has been derived from studying the well known and admirable "Principles of Geology."

The five years of the voyage filled the twenty-second to twenty-seventh years of Darwin's life, the period now ordinarily given to professional studies. In reading this simply written but fascinating book, which stands quite by itself in literature, we see how Darwin through his own genius and through the methods successively impressed upon him by his father, by Henslow, by Sedgwick and by Lyell was unconsciously preparing his mind for the "Origin of Species" and the "Descent of Man," the two most influential books of science which have ever appeared. From the islands of the Atlantic and the Pacific we follow his delightful comments on animals and plants of all kinds on sea and land, through forests, pampas and steppes, up the dry slopes of the Andes, along the salt lakes and deserts of Chili and of Australia. The dense forests of Brazil pendent with orchids and gay with butterflies contrast with those of Terra del Fuego and of Tahiti, and with the deforested Cape de Verde Islands. On these islands, the first he visits, he is enormously impressed by the superiority of Lyell's method. He visits other islands of all kinds, inhabited and uninhabited, the non-volcanic St. Paul's rocks, half-submerged volcanic cones, coral reefs and islands of the south Pacific. He observes live glaciers, as well as the contrasting action of active and of dead volcanoes. Along the rivers of Patagonia he unearths great extinct or fossil mammals; in Peru he studies the extinct races of man; the aborigines of Terra del Fuego and of Patagonia make the most profound impression upon his mind. In brief, he sees the great drama of nature in all its lesser scenes and in all its grander acts. He begins the voyage a firm believer in the fixity of species, but doubts begin to enter his mind when in the sands of the pampas of South America he perceives that the extinct forms are partly ancestral to the living, and when on the isolated Galapagos Islands he finds the life is not that of a special creation but that detached from the continent of South America six hundred miles distant.

Darwin says:

> I owe to the voyage the first real training and education of my mind. That my mind had developed is rendered probable by my father's first exclamation on my return, "why the shape of his head is quite altered."

III

Soon after Darwin's return he moved to London for the two most active years of his life, to care for his collections and to write up his

observations. At this moment came the third of the great turning points in his life, which as a mysteriously disguised blessing was brought about through ill health. In London he was entering official duties and public scientific service which would undoubtedly have increased and interfered more and more seriously with his work. We can only count it as one of the most fortunate circumstances in the history of science that Darwin at the age of thirty-three was forced to leave London and to move to Down. Here for forty years he never knew for one day the health of an ordinary man; his life was one long struggle against the strain of sickness. But unrealized by him there was the compensation of a mind undisturbed by the constant interruption of outside affairs, such interruption as killed Huxley and is killing so many fine and ambitious men to-day. When I saw Huxley and Darwin side by side in 1879, the one only fifty-four, the other seventy, the younger man looked by far the more careworn of the two. Huxley, the strong man, broke down mentally at fifty-six; Darwin, the invalid, was vigorous mentally at seventy-two.

Darwin's writings fall into three grand series. In the nine years after he returned from the voyage, or between his twenty-seventh and thirty-sixth years, Darwin wrote the first series, including his pre-evolutionary geological and zoological works, his "Coral Reefs" (1842), his "Zoology and Geology of the Voyage of the *Beagle*" (1844–1846), his "Journal of Researches," the popular narrative of his voyage (1845). Darwin's ill health thereafter shut him off from geology, although his last volume, "The Earthworm," was in a sense geological.

It is characteristic of the life of every great man that his genius and his own self-analysis instinctively guide him to discover his mental needs.

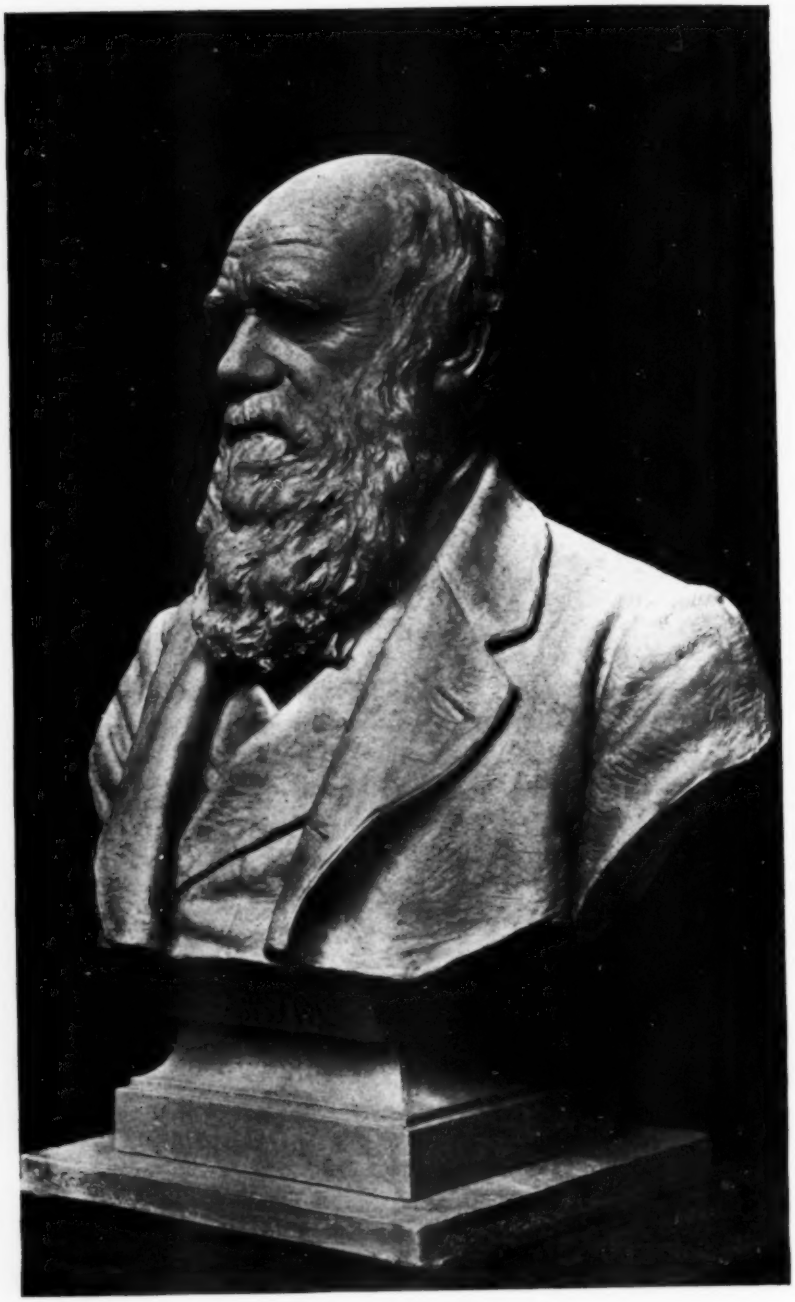
Until the age of forty-five Darwin in his own opinion had not completed his education, in the sense that education is a broad and exact training. He now proceeded to fill the one gap in his training by devoting the eight years of his life, between thirty-seven and forty-five, to a most laborious research upon the barnacles, or Cirripedia. This gave him the key to the principles of the natural or adaptively branching and divergent arrangement of animals through the laws of descent as set forth in the "Origin," which he certainly could not have secured in any other way. The value he placed on his work on the barnacles is of especial import to-day when systematic work is so lightly esteemed by many biologists, young and old. Darwin subsequently, in the words of Hooker, "recognized three stages in his career as a biologist, the mere collector at Cambridge, the collector and observer on the *Beagle*, and for some years afterwards, and the trained naturalist after, and only after, the Cirripede work."

Long before this, however, at the age of twenty-eight, Darwin had begun his career as a Darwinian. In July, 1837, he began his notes on the transmutation of species, based on purely Baconian principles, on the rigid collection of facts which would bear in any way on the variations of animals and plants under domestication and in nature. Rare as was his reasoning power, his powers of observation were of a still more unique order. He persistently and doggedly followed every clue; he noticed little things which escaped others; he always noted exceptions and at once jotted down facts opposed to his theories. On the voyage the marvelous adaptations of animals and plants had been his greatest puzzle. Fifteen months later, in October, 1838, in reading the work of Malthus, on "Population," there flashed across his mind the three-fold clue of the struggle for existence, of constant variability, and of the selection of variations which happen to be adaptive.

The three memorable features of Darwin's greatest work, "The Origin of Species," are, that he was twenty-one years in preparing it, that, although by 1844 he was a strongly convinced evolutionist and natural selectionist, he kept on with his observations for fifteen years, and the volume even then would have been still longer postponed but for a wonderful coincidence, which constitutes the third and not the least memorable feature. This coincidence was that Wallace had also become an evolutionist and had also discovered the principle of natural selection through the reading of the same essay of Malthus. It is further remarkable that of all persons Wallace selected Darwin as the one to whom to send his paper. It was then through the persuasion of the great botanist Hooker, who had known Darwin's views for thirteen years that these independent discoveries were published jointly on July 1, 1858. All the finest points of Darwin's personal character were displayed at this time; in fact, the entire Darwin-Wallace history up to and including Wallace's noble and self-depreciatory tribute to Darwin on July 1, of last summer, is one of the brightest chapters in the history of science. Wallace himself pointed out the very important distinction that while the theories contained in the two papers published fifty years ago were nearly identical, Wallace had deliberated only three days after coming across the passage in Malthus, while Darwin had deliberated for fifteen years. He modestly declared that the respective credit should be in the ratio of fifteen years to three days.

Several months past the age of fifty Darwin published his epoch-making work (November, 1859), and despite ill health, between fifty and seventy-three, he produced the nine great volumes which expand and illustrate the views expressed in "The Origin of Species."

A parallel to this remarkable late productiveness is that of Kant, who also put forth his greatest work after fifty. Let those past the five



decades take heart, for it appears that while there are inborn differences between men in this regard, imagination, observation, reasoning and production do not necessarily dim with age. Darwin's mind remained young and plastic to the end; his latest and one of his most characteristic works, "The Formation of Vegetable Mould through the Action of Earth Worms" was published at the age of seventy-two, after forty-four years of observation. It contained another and perhaps the most extreme demonstration of Lyell's principle that vast changes in nature are brought about by the slow operation of infinitesimal causes.

Three of Darwin's succeeding volumes are a filling out of the "Origin." "The Variation of Animals and Plants under Domestication" (2 vols., 1868) presents the entire fabric of the notes begun twenty-one years before on the transmutation of species. "The Descent of Man" (1871) was another logical outcome of the "Origin," yet it was only faintly adumbrated by a single allusion in that work to the fact that the transmutation of species necessarily led to the evolution of man. The "Descent" marks the third of the great dates in the history of thought, as the "Origin" marks the second, because it is the final step in the development of ideas which began with Copernicus in 1543. The world-wide sensation, the mighty *storm* produced by this bold climax of Darwin's work, is so fresh in the memory of all that a mere allusion suffices. The evolutionary or genetic basis for modern psychology as stated in "The Descent of Man" was given still more concrete form in Darwin's succeeding and most delightful volume "The Expression of the Emotions" (1872).

The knowledge of zoology and anatomy displayed in these four evolutionary volumes came from direct observation, vast and systematic reading and note-taking from the simple materials which Darwin could collect at Down. Always penetrating as these observations are, they are still, in my opinion, surpassed in beauty and ingenuity by his marvelous work on plants, published between 1862 and 1880. Here the principles of coadaptation of plants and insects in cross- and self-fertilization, in climbing plants and insectivorous plants, in forms of flowers, in movements of plants, are all brought forth in support of the theory of natural selection and the operation of unknown laws. Darwin's most precise observations and some of his most brilliant discoveries recorded in these volumes laid the foundations of modern experimental botany.

Of his method Darwin writes:

> From my early youth I had the strongest desire to understand or explain whatever I observed, that is, to group facts under some general laws. My mind seems to have become a kind of machine for grinding general laws out of large collections of facts.

The only work which Darwin wrote deductively was his "Coral

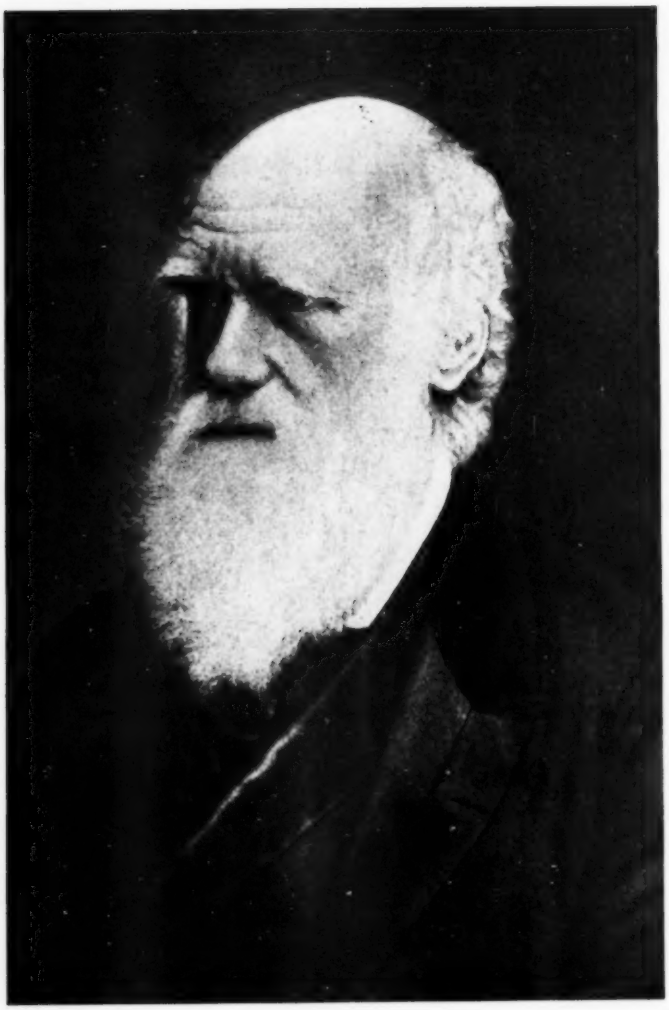
Reefs." Every other volume came through the inductive-deductive process, that is, through an early assemblage of facts followed by a series of trial hypotheses, each of which was rigidly tested by additional facts. The most central of these trial hypotheses was that of the building up of adaptations through the selection of the single adaptive variation out of the many fortuitous variations, and this Darwin was unable to rigidly test by facts but was obliged to leave for verification or disproof by work after him.

Darwin passed away in the year 1882, at the age of 73. Out of the simple and quiet life at Down he had sent forth the great upheaval and revolution.

IV

There is no denying that there is to-day a wide reaction against the central feature of Darwin's thought and this leads us to consider the merits of this reaction, as will be more clearly and fully set forth in the succeeding lectures of this series.

Now on this centenary when we are honoring Darwin, many may ask, exactly what is Darwinism? Failure to know leads some to doubt, others to predict a decline, especially where "the wish is father to the thought." Nothing could be less true than to say that there is the least abatement in the force of the main teaching of this great leader, namely, of the evolutionary law of the universe. The vitality of this idea is shown by its invasion of the physical world. Again, Darwinism is the sum of Darwin's observations on earth structure, on plants, animals and man. This vast body of truth and of interpretation still so far surpasses that brought forward by any other observer of nature, and these facts and interpretations are so far confirmed that they have become the very foundation stones of modern biology and geology. Finally, looking at Darwinism as the sum of his generalizations as to the processes of evolution we again find a vast body of well established laws which are also daily becoming more evident. As to the laws of evolution, there is no single biological principle more absolutely proved by the study of living and extinct things since Darwin's time than the broad law of natural selection: certainly the fittest survive and reproduce their kind, the fittest of every degree, classes, orders, genera, species, individuals and even the fittest organs and fittest separate parts of organs. Darwin still gives us the only explanation which has ever been suggested of hundreds of thousands of adaptations of which neither Buffon's view of direct effect of environment nor Lamarck's view of the inheritance of bodily modifications even approach an explanation worthy to be considered. Take the egg of the murre or guillemot, which is so much larger at one end than the other that it can not roll off the cliff on which it is laid, or the seasonal changes of color in the ptarmigan, every one of which is protective.



There is some lack of perspective, some egotism, much one-sidedness in modern criticism. The very announcement, "Darwin deposed," attracts such attention as would the notice "Mt. Blanc removed"; does it not argue courage to attack a lion even when deceased? Preoccupation in the study of one great law, as in the case of Bateson on Mendelism and De Vries on Mutation blinds to every other law. To be dispassionate, let us remember that Darwin's hypothesis was framed in 1838, seventy years ago. Are the two great Cambridge men, Newton and Darwin, lesser men because astronomy and biology are progressive sciences? Secondly, to know your Darwin you must not judge him by single passages but by all he wrote. Darwin is not to be known through the extremes of those of his followers with whom an hypothesis has become a creed. Reading him afresh and through and through we discover that his "variation" and "variability" are very broad and elastic terms. Every actual example he cites of his main hypothesis, such as the speed of the wolf, or the deer, or the long neck of the giraffe, is a variation both heritable and of adaptive value.

When we put together all the concrete cases which he gave to illustrate his views of selection we see that he includes both continuous and discontinuous variations, both the shades of difference of kind and proportion and the little leaps or saltations from character to character. For example, certain cases of immunity to disease are now known to be "unit characters" in Bateson's sense, or "mutants" in the De Vries sense. Darwin repeatedly referred to immunity as a variation which would be preserved by selection. Moreover, Darwin's own repeated assertion of his profound ignorance of the laws of variation certainly pointed the way to the investigation of these laws, and it is this very study which is modifying the applications of his selection hypothesis.

From first to last Huxley maintained that it would require many years of study before naturalists could say whether Darwin had been led to overestimate the power of natural selection. Darwin's mind from first to last was also open on this point. Through every edition of the "Origin" we find the passage:

> The laws governing the incipient or primordial variations (unimportant except as the groundwork for selection to act on and then all important) I shall discuss under several heads. But I can come, as you may well believe, to only very partial and imperfect conclusions.

In 1869 and in the latest edition of the "Origin" Darwin speaks of "individual differences" as of paramount importance, but he illustrates these differences by such instances as the selection of passenger pigeons with more powerful wings, or the selection of the lightest colored birds in deserts.

There can be no question, however, that Darwin did love his selection theory, and somewhat overestimated its importance. His conception of selection in nature may be compared to a series of concentric circles constantly narrowing from the largest groups down to the minutest structures. In the operations of this intimate circle of minute variations within organisms he was inclined to believe two things: first, that the fit or adaptive always arises out of the accidental, or that out of large and minute variations *without direction* selection brings direction and fitness; second, as a consistent pupil of Lyell, he was inclined to believe that the chief changes in evolution are slow and continuous. The psychology of the former is that he was in a reaction state from the prevailing false teleology. He was not expecting that purposive or teleological or even orthogenetic laws of variation would be discovered. William James has thus recently expressed and endorsed the spirit of Darwinism as a natural philosophy in the followwords:

> It is strange, considering how unanimously our ancestors felt the force of this argument [that is, the teleological], to see how little it counts for since the triumph of the Darwinian theory. Darwin opened our minds to the power of the chance-happenings to bring forth "fit" results if only they have time to add themselves together. He showed the enormous waste of nature in producing results that get destroyed because of their unfitness.

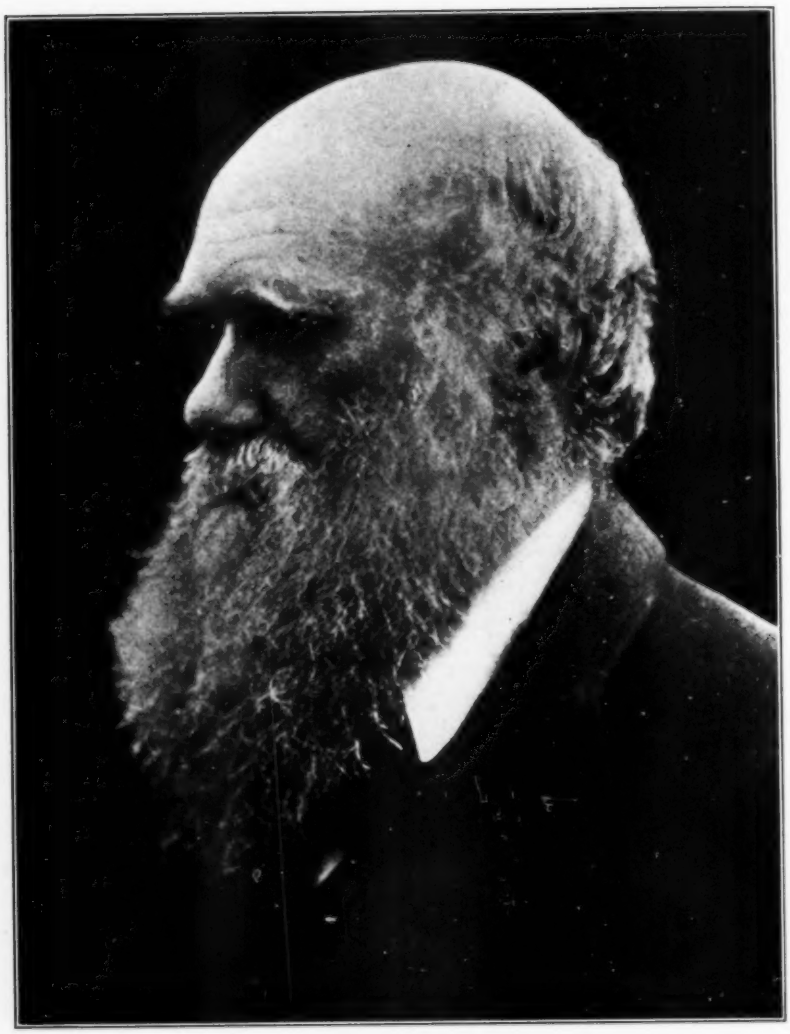
The simple question before us to-day and in the succeeding lectures of this course is: *is this true?* This really involves the deep seated query whether the intimate or minute parts of living things are operating under natural laws like non-living things, or are really lawless.

Before expressing my individual opinion based on my own researches of the last twenty years I may summarize the general modern dissent: in *three points* it may be said that Darwin's teachings are not accepted to-day.

First, his slowly developed belief in the inheritance of bodily modifications as well as the provisional "assemblage theory" of heredity which he called *pangenesis,* have been set aside for Weismann's law that heredity lies in the continuity of a specific heredity plasm, and for want of evidence of the transmission of acquired characters.

Second, while his prevailing belief that changes in organisms are in the main slow and continuous is now positively demonstrated to be correct by the study of descent in fossil organisms, there is also positive evidence for the belief which he less strongly entertained that many changes are discontinuous or mutative, as held by Bateson and De Vries.

Finally, his belief that out of fortuitous or undirected variations in minute characters arise direction, purpose and adaptation through selection still lacks proof by either observation or experiment. Fossil



and other descent series entirely unknown in Darwin's time certainly prove beyond question that law rather than chance is prevailing in variation.

What the nature of these laws is it is still too early to say. Personally I am strongly of the opinion that the laws of life, like the ultimate laws of physics, may ultimately prove to be beyond analysis.

To allow myself just one flight of fanciful statement drawn from personal observation and reflection I may say there is a likeness between the unit forces working in a single organism, both as revealed by the microscope and in fossil series, and the individual soldiers composing a giant army. The millions of well-ordered activities in the body correspond with the millions of intelligently trained men who compose the army; the selection process or the survival of the fittest is like the competition between two armies, between the Russian and Japanese, for example. It is an outward and visible competition between two internally prepared and well-ordered hosts of units and groups of units. Selection is continuously working upon the army as a whole and also upon every unit which affects survival—an immunity unit, an intelligence unit, a speed unit, a color or group of color units; just as in the army it is working upon units of courage, of strategy, of precision of fire, of endurance, of mass. In this sense it is perfectly true to say with Darwin "that selection works upon certain single variations." It is not true or at least it is not shown, that these variations are a matter of chance; they rather appear to be a matter of law as indeed Darwin foresaw when he stated that he used the word "chance" merely as a synonym of "ignorance."

In the present state of biology we are studying the behavior of the thousands of parts, sometimes of blending, sometimes of separate, sometimes of paired or triplicate units, which compose the whole and make up the individual organism. Natural selection determines which organism shall win; more than this, it determines which serviceable activities of each organism shall win. Here lie the limits of its power. Selection is not a creative principle, it is a judicial principle. It is one of Darwin's many triumphs that he positively demonstrated that this judicial principle is one of the great factors of evolution. Then he clearly set our task before us in pointing out that the *unknown* lies in the laws of variation and a stupendous task it is. At the same time he left us a legacy in his inductive and experimental methods by which we may blaze our trail.

Therefore, in this anniversary year, we do not see any decline in the force of Darwinism but rather a renewed stimulus to progressive search. As Huxley says:

> But this one thing is perfectly certain—that is, it is only by pursuing his method, by that wonderful single-mindedness, devotion to truth, readiness to sacrifice all things for the advance of definite knowledge, that we can hope to

come any nearer than we are at present to the truths which he struggled to attain.

V

On December 8, 1879, when Darwin was in his seventieth year and I in my twenty-second, I had the rare privilege of meeting him and looking steadily in his face during a few moments' conversation. It was in Huxley's laboratory, and I was at the time working upon the anatomy of the Crustacea. The entry in my journal is as follows:

This is a red letter day for me. As I was leaning over my lobster (*Homarus vulgaris*) this morning, cutting away at the brain, I raised my head and looked up to see Huxley and Darwin passing by me. I believe I never shall see two such great naturalists together again. I went on apparently with skill, really hacking my brain away, and cast an occasional glance at the great old gray-haired man. I was startled, so unexpected was it, by Huxley speaking to me and introducing me to Darwin as "an American who has already done some good paleontological work on the other side of the water." I gave Darwin's hand a tremendous squeeze (for I never shall shake it again) and said, without intending, in an almost reverential tone, "I am very glad to meet you." He stands much taller than Huxley, has a very ruddy face, with benevolent blue eyes and overhanging eyebrows. His beard is quite long and perfectly white and his hair falls partly over a low forehead. His features are not good. My general impression of his face is very pleasant. He smiled broadly, said something about a hope that Marsh with his students would not be hindered in his work, and Huxley saying, "I must not let you talk too much," hurried him on into the next room.

I may add as distinctly recorded in my memory, that the impression of Darwin's bluish-gray eyes, deepset under the overhanging brows, was that they were the eyes of a man who could survey all nature.

Another memory of interest is that the instant Huxley closed the door I was mobbed as the "lucky American" by the ninety less fortunate students of Great Britain and other countries.

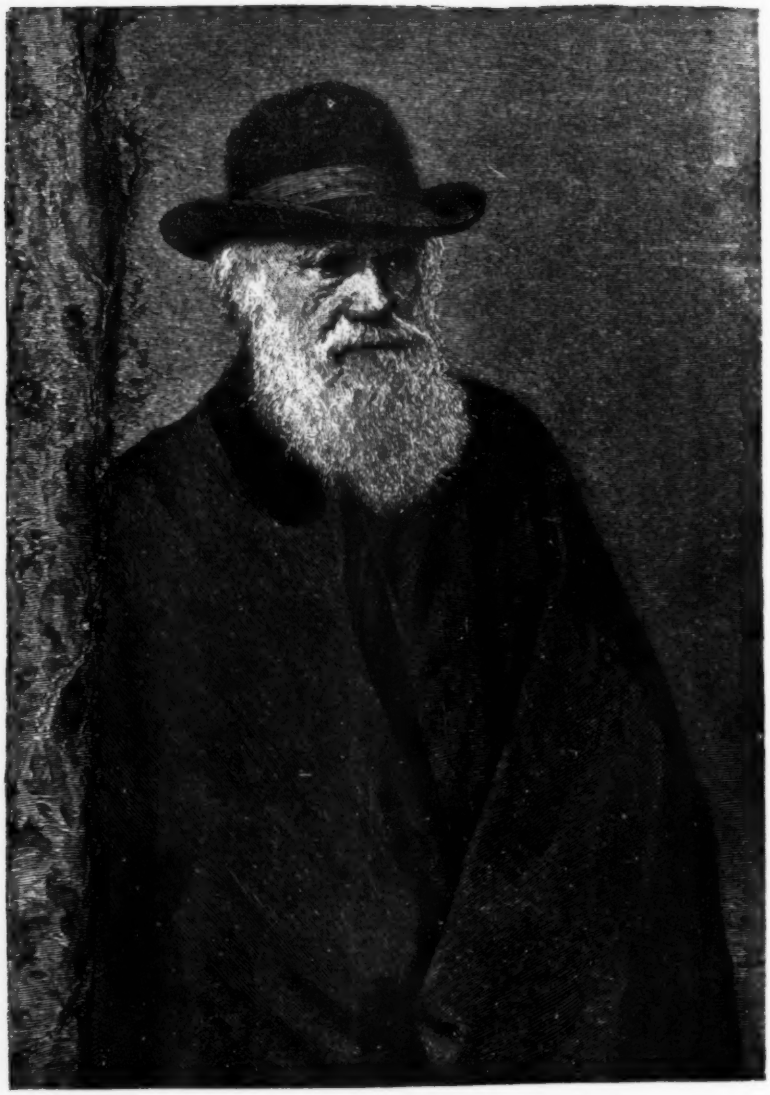
Huxley's solicitude for Darwin's strength was characteristic of him. He often alluded to himself as "Darwin's bull dog."

I have already stated that of the two men Darwin gave the impression of enjoying better health. Huxley was then sixteen years the younger, yet the burdens and strain of London life made him look less young and hale. In this connection an earlier jotting from the same laboratory is as follows:

Huxley comes in as the clock strikes and begins to lecture at once, almost before it ceases. He looks old and somewhat broken, his eyes deeply sunken, but as a lecturer as strong as he ever could have been. His language is very simple too.

VI

What of the conflict between science and theology? We are now in a process of readjustment, but let us imagine our descendants in



Ch. Darwin

this university three or four hundred years hence looking back on the history of man. With larger perspective they will see two grand thought movements; the first, oriental, marked by oriental lack of curiosity about natural law, a great moral and spiritual movement developing along the Nile, the Tigris and Euphrates, out of five thousand years of hard human experience, culminating in Judea in the faith that nature is the continuous handiwork of God, in a supreme standard of righteousness, and in the simple expression of the human law "thou shalt love thy neighbor as thyself."

Another movement begins six centuries earlier in the inquiring mind of the west, always characterized by curiosity about nature. It was the search for natural law. Its rapid progress among the Greeks sadly terminates with the fall of Greece. After nineteen centuries it revives with Copernicus and Galileo and culminates in Darwin. Man is a part of nature; in the study of nature man finds intellectual delight; in the laws of nature man finds his physical welfare.

The conflict of opinion aroused by Darwin will subside like the evil passions of our Civil War. Surely the reverent study of nature can not lead man astray. These two great movements of love and of knowledge, first of the spiritual then of the intellectual and physical well-being of man, will be seen to be a harmony and not a discord.

THE INDIVIDUALITY OF CHARLES DARWIN

By CHARLES F. COX
PRESIDENT OF THE NEW YORK ACADEMY OF SCIENCES

WE are assembled, at the invitation of an organization devoted to the dissemination of scientific knowledge, under the hospitable roof of an institution maintained for the promotion of systematic observation, for the purpose of honoring the memory of one of the greatest of seers. Charles Darwin, whose birthday we celebrate, was a man of the clearest mental vision born into a generation scientifically blind. He first, of those in his day accounted wise, was able to see all nature unfolding according to uniform and verifiable law. The outlook of other men called by his contemporaries scientists and philosophers was, as a rule, limited and obscured by a narrowing and hampering doctrine of supernatural intervention. It is hard for us, who are privileged to contemplate with admiring minds the harmonious interrelations of all natural phenomena, to realize that only fifty years ago it was commonly regarded as both irrational and immoral to believe that one great principle underlay the origin, maintenance, diversification and development of living forms and that that principle was discoverable through human investigation. During the ages previous to the memorable year 1859 a few bold thinkers, now and then, had ventured to suggest a theory of general evolution, but they had failed to supply it with a substantial foundation of proof, or to assign to it a reasonable and intelligible cause, and had been, consequently, one and all, overwhelmed and suppressed by the powerful and prevalent dogma of special creation. Naturalists had been for centuries active in the collection of facts, but, until Darwin came, the various phenomena of living things remained disconnected and unexplained. Indeed, it was impossible that they should have been correlated and elucidated as long as the domain of science was in thralldom to tyrannical authority and originality of thought was little less than a crime. For a hundred years prior to Darwin even professed students of nature were not free to see what lay under their very eyes. The scientific world was awaiting a liberator. Finally the revolution was proclaimed and the first decisive blow struck by the publication of "The Origin of Species" on the twenty-fourth of November, 1859. It was no hasty and ill-considered

[1] An address given at the American Museum of Natural History on February 12, on the occasion of the presentation of a bust of Darwin by the New York Academy of Sciences to the museum.

stroke. Events had been shaping themselves to this end since the twenty-seventh of December, 1831, when the little brig *Beagle* sailed from Plymouth harbor, bearing the unknown and youthful Charles Darwin to the discovery of a new world—not, however, an unexplored continent to be claimed for commerce and civilization, but a vastly greater and more valuable realm of thought to be opened to knowledge and conquered for intellectual freedom. Darwin, like the prophets of old, in preparation for his exalted mission, betook himself to the uninhabited wilderness, away from the influence of other minds, in order that he might draw inspiration from untrammeled and clarifying communion with nature. In his narrow cabin on the broad Atlantic, on the desert plains of Patagonia, on desolate and unpeopled islands of the Pacific, in the dark and solemn forests of the tropics, and on the summits of the bleak and barren Andes he gained the coveted prize of wisdom which had been denied him in the populous halls of two great universities where his free spirit had rebelled against the narrow conventionality of classical education.

Although a born investigator he had been driven and harassed for fourteen years by unthinking instructors devoid of both the ability and the disposition to consider his natural endowments and inclinations and who, with one or two exceptions, according to his own later judgment, wasted their time upon an unappreciative and discouraging pupil. He says of himself that he was slow in learning, but a review of his productive life clearly shows that, if he was dull in any respect, it was solely in the matter of accepting ideas at second hand. It happened, merely, that what most of his teachers were prepared to impart he was not constituted to receive; and so one of the acutest observers the world has ever known was thought to be inattentive and unreceptive. During all the school days of his childhood, passed in his native town of Shrewsbury, not only were his superb mental gifts wholly unrecognized, but no attempt was ever made to find out if he had any such gifts. He spent seven useless years at Dr. Butler's so-called "great school," but, apparently, the head master never came to know his talented pupil, for the educational system which prevailed in that institution had no reference to "the discovery of the exceptional man." The one ceaseless effort of his schoolmasters was to crowd him into the common mold.

Receiving no sympathy and little assistance from the teachers of his boyhood, he developed "a strong taste for long solitary walks" and cultivated the habit of stealing time for more or less surreptitious collecting in several departments of natural history. Thus he became, in all important respects, self-taught and, driven to his own resources, his natural inclination to consider his path of life as lying far aside from the common highway was confirmed and strengthened. This sense of solitariness followed him to the end of his life and was, no doubt, an

important factor in the formation and preservation of his extraordinary individuality and faith in his own powers. Darwin's followers may therefore bless even the obtuseness and unwisdom of his preceptors who left him unspoiled by their restraining influence.

When, in 1825, Doctor Robert Darwin concluded that his son Charles was lacking in natural aptitude for scholarship, he sent him to Edinburgh University, intending that he should follow in the footsteps of his father and of his grandfather by becoming a physician. But here, again, the young man found himself unable to receive what was offered him on the strength of ancient authority. The instruction dispensed in that hoary institution was, to him, perfunctory and uninspiring and he was once more driven to seek the real enlargement of his knowledge by self-directed methods. In this way he appears to have obtained, at Edinburgh, some sort of acquaintance with the fundamental principles of scientific research, but, as the learning thus acquired was not in the line of his intended profession, it was not appreciated by his family and friends. Accordingly, after two sessions spent at that university, it was concluded that his regular studies had been entirely misdirected and he was therefore withdrawn and sent to Cambridge. There he was still worse misguided in the endeavor to educate him in theology. Again was repeated the old story of an uncongenial curriculum ostensibly conformed to but in reality shirked and avoided in favor of natural history privately followed by side paths. The unwilling student wished to be obedient to his father's direction, but native bent proved stronger than conventional rule—the call of destiny louder than the voice of filial duty.

His father, in most things a wise man, saw in his son's insect- and bird-hunting proclivity a tendency to the life of "an idle sporting man" and was sorely grieved and disappointed when he was obliged to concede the failure of his plan to connect the house of Darwin with the Church of England. Fortunately, however, the youthful Darwin came under the influence, at Cambridge, of a teacher endowed with more than ordinary discernment and, in this particular matter, with somewhat unusual independence and courage, and he took the budding naturalist and his lawless pursuits under his patronage and protection. To the faith and friendship of Professor J. S. Henslow Darwin was indebted for his appointment to the *Beagle* expedition, and to Professor Henslow, who robbed the church to enrich science, the world owes an incalculable debt of gratitude for the discovery, if not for the development, of one of its loftiest geniuses.

Others besides Henslow, however, had contributed to the fixation of Darwin's inborn talents and abilities, but Darwin never admitted that he received, either at Edinburgh or at Cambridge, anything like systematic mental training. He was, from the beginning of his school

days to the end of his university life, a person set apart for individual preparation for a special and peculiar career. When he bade farewell to Christ's College, Cambridge, in the summer of 1831, his actual education was yet to be acquired, but not through human instruction. He has himself declared: "I have always felt that I owe to the voyage the first real training or education of my mind."

It was therefore no professional scientist who eagerly accepted the unsalaried post of naturalist to the *Beagle* expedition around the world, but a modest, though confident, youth of twenty-two whose most important article of outfit was the first volume of the first edition of Lyell's "Principles of Geology," which had been published the year before, the second volume of which was not issued until after Darwin had reached South America. Thus it was providentially ordered that during the formative period covered by this epoch-making voyage, Darwin should remain as free as possible from human influences. If, instead of proceeding, raw as he was, directly from the seclusion of the university to the isolation of the voyage, he had directed his steps to the metropolis and had there mingled with the leaders in scientific thought, it is quite possible, if not probable, that he would have fallen under their authority and would have accepted the orthodox beliefs of his time. If that had been the case, we might be dominated to-day by the prohibitive doctrine of the immutability of species, instead of enjoying that freedom of thought and liberty of investigation to which Darwin made us heirs. But, happily for the intellectual world, during the five years which Darwin spent on the *Beagle,* under the intimate tutelage of mother nature, he laid, for our benefit, as well as for his own, the solid foundations of that never-failing habit of mind in which open-eyed teachableness ever supplemented unwavering honesty of purpose and fearlessness of approach.

After Darwin's return from the circumnavigation of the globe, he resided, for a little more than five years, in London, and that was the only portion of his life during which he was in actual personal contact with any considerable number of his fellow men. Even then, however, he was mostly engaged with his own thoughts, for he was arranging his collections and preparing for publication the results of his observations made while on the *Beagle* voyage. It was at the very beginning of this residence in London (July, 1837), while the things he had seen in South America and the Pacific Islands were still fresh in his memory that he opened his first note-book for facts in relation to the origin of species, about which he says he "had long reflected." For twenty-two years thereafter Mr. Darwin continued to pursue this revolutionizing subject with unexampled patience and, except as to two or three intimate friends, entirely within the privacy of his own mind.

In September, 1842, he went into retirement at Down, an out-of-

the-way village in Kent. There, partly compelled by ill-health, he dwelt as a recluse for forty years, serenely contemplating nature and diligently gathering information, but seldom emerging into the world from which his richly-stored and phenomenally creative intellect had little to gain, but to which it never ceased to give, during the remainder of his life. Bare knowledge he welcomed from any source, but opinions and deductions he invariably produced for himself. What he wrote to H. W. Bates, who complained of a want of advice, is true of Darwin himself: "Part of your great originality of views," he said, "may be due to the necessity of self-exertion of thought." What has been said by his son Francis is equally true of Mr. Darwin—one of his most striking characteristics was "that supreme power of seeing and thinking what the rest of the world had overlooked."

Mr. Darwin was what we are accustomed to call a genius, but I know of no good definition of a genius but *a man of insight*. The person who by his unaided mental vision is able to see into and through problems which to other men are baffling or insoluble, has the highest right to be considered inspired. Darwin's wonderful endowment in this respect constituted him, by divine right, a leader of men. The world has always justly honored its standard bearers and we are here to pay homage to the name of one of the most attractive and commanding of them all. In other parts of this city and of this land, our fellow-citizens are gathering to-day to pay grateful tribute to the estimable character, and to recall the memorable deeds of a great emancipator. We likewise are celebrating the beneficent acts of a man, simple and modest as that other, who, at a critical period, spoke courageous words which conferred freedom on millions of his fellow creatures. It is altogether fitting that the birthdays of these two benefactors should be the same.

We now dedicate this monument in this approprite place not only to the honor and memory of Charles Darwin the great thinker, whose life and personality we admire, but also to the encouragement and guidance of all who may hereafter frequent these halls—as a testimony to the power of self-reliance and independence of mind which Charles Darwin preeminently exemplified and illustrated. May this portrait of a noble truth-seeker which we now unveil, signify, for all time to come, to him who would advance the boundaries of scientific knowledge that nature will yield up her secrets only when appealed to directly and in humility and purity of spirit.

DARWIN AND GEOLOGY[1]

By Professor JOHN JAMES STEVENSON
NEW YORK UNIVERSITY

CHARLES DARWIN was born in a time of intellectual unrest. Explorers, students of chemistry and workers in mines had been adding to actual knowledge for nearly one third of a century and thoughtful men had been forced to recognize the worthlessness of many conceptions which had long passed current. Nowhere was this unrest more manifest than among the younger geologists; but they were compelled to express themselves cautiously, for, fettered by a false chronology, the church dignitaries who controlled the universities rebuked investigation and branded as infidels those who recorded obnoxious facts. Little more than a year prior to Darwin's birth, the Geological Society of London had been founded as a protest against subjective study of this globe, but already many adherents to the principles of that society had appeared on the continent, proclaiming that actual knowledge of conditions must precede attempts to explain them.

The development of opinion was so rapid that before Darwin reached his majority the geological pendulum had made its great swing from the doctrine of cataclysms to that of uniformity; from the belief that this globe is less than 6,000 years old to an abiding faith that its age can not be measured in years. It was amid such conditions that toward the close of his university studies, he came under the influence of Henslow and Sedgwick, the latter being engaged at that time along with Murchison in an effort to unravel the tangle of Welsh geology. Some have said that these men taught him how to observe; not so; he was already a keen observer and they merely led him into wider fields.

In 1831, Captain Fitzroy was assigned to command H. M. S. *Beagle*, a little brig of 240 tons, and was commissioned to complete the coast survey of southern South America as well as to run a line around the globe. When he expressed the wish to be accompanied by a naturalist, Darwin, then only twenty-two years old, promptly volunteered his services, which were accepted, and he was enrolled as a supernumerary member of the staff. The *Beagle* left England on December 27, 1831, and returned on October 2, 1836, bringing with it Charles Darwin, now grown intellectually to man's stature and bearing a notable cargo of material collections as well as of accumulated observations. There

[1] An address given at the American Museum of Natural History on February 12.

was no haste in publication; aside from some very brief communications to societies, nothing appeared until 1839, when the *Journal of Researches* was printed. Owen's descriptions of the fossil mammalia was issued in 1840 with an introduction by Darwin and the final publication of results was made in three parts, dated 1842, 1844 and 1846. Thus early in his career, Darwin showed that caution which characterized him throughout life, an indifference to priority which was the outgrowth of his love of accuracy.

Part 2 of the "Geological Observations," dated 1844, relates chiefly to volcanic islands. In most cases the stay at those was brief and the studies were fragmentary; yet Darwin saw enough to let him discuss the origin of volcanic cones, to determine some cardinal points respecting the distribution of the islands, to distinguish submarine from subaerial lava flows and to prove that experimental studies on metamorphosis of limestones had led to very nearly true conceptions of the process.

As the coast survey of southern South America was the important object of Captain Fitzroy's expedition, there was ample time for a good reconnaissance of that region and Darwin spent nearly six months in studying the pampas from the Parana and Uraguay rivers southward almost to Magellan's Strait. A synopsis was given as an introduction to Owen's Memoir, but the details did not appear until 1846, when they were published as Part 3 of the "Geological Observations." The whole subject was discussed attractively in the second edition of the *Journal of Researches.*

The superficial deposit of the great plains is a "reddish argillaceous earth" containing concretions of indurated marl, which at times become continuous layers or even replace much of the red earth. In the northerly part of the plains-area, this pampas deposit, which passes downward into sands, limestones and clays of late Tertiary age, yielded no marine shells to Darwin; its infusoria, studied by Ehrenberg, proved to be partly marine, partly freshwater, while the marly concretions resemble some freshwater limestones seen in Europe; but this paucity of invertebrate life was unimportant, for the whole of that region proved to be one vast cemetery, in which the skeletons of gigantic extinct mammals are so numerous that a line could not be drawn in any direction without passing through some bones. In northern Patagonia the red deposit is bound closely to an overlying gravel, containing marine forms belonging to species now existing on the coast, while in southern Patagonia marine shells occur in the pampas deposit itself.

Darwin believed that this pampas material was deposited within a vast estuary, into which great rivers carried from the surrounding region carcasses of the animals whose skeletons were entombed in

muds tranquilly accumulating on the bottom. All conditions go to show that the mammalia became extinct after the sea had received its present fauna; and there is nothing to suggest that a period of overwhelming violence swept away and destroyed the inhabitants of the land; everything supports the contrary belief. The only noteworthy change in conditions has been a gradual elevation of the continent; but that was not enough to modify the climate or to bring about a change in the land fauna.

Several of the important genera collected by Darwin had been found in North America long prior to his time. This similarity of the Quaternary faunas induced him to speculate on the causes which had divided the American continent into two well-defined and somewhat contrasting zoological provinces. He does not hesitate to suggest recent elevation of the Mexican platform or more probably, recent submergence of the West Indian Archipelago as a conceivable cause of this separation. It seems to him most probable that the elephants, the mastodons, the horses and the hollow horned ruminants of North America "migrated, on land since submerged near Behring Straits, from Siberia into North America, and thence, on land since submerged in the West Indies, into South America, where for a time they mingled with forms characteristic of that southern continent and have since become extinct." Had this American Museum of Natural History existed in Darwin's day, study of the remarkable exhibits in its Mammalian Hall would have enabled him to extend his list of extinct forms common to both continents, and possibly he might have anticipated some of the all-important generalizations for which the world is indebted to the former president of this academy, who now is president of the museum.

Nothing in South America, east or west, escaped Darwin; from glaciers to peat bogs, from earthquakes to climatal variations, everything was important; but what impressed him most on both sides of the continent were the evidences of extremely slow secular movement in the earth's crust. This was the preparation for that study of the coral islands which resulted in his chief contribution to philosophical geology.

Many voyagers prior to 1833 had observed and had tried to account for the strange atolls, or low ring-like coral reefs, each enclosing a lagoon which communicates with the sea by a narrow channel; but Darwin discovered other forms of reefs which were equally perplexing. Many islets of rock are fringed by coral growth, while vast barrier reefs, separated from the land by channels of varying depth, extend at times for hundreds of miles along coasts. All explanations by previous observers were defective as they seemed to ignore these types as well as other features, not less important.

Reef-making corals can not endure exposure to the air and they can not thrive at a depth of more than 20 fathoms, so that their vertical range is about 115 feet; yet hooks and anchors brought up coral rock and sand from many hundreds of feet below the limit of growth; in a great number of instances, the atolls or ring-like reefs are mere peaks rising with abrupt slopes from "fathomless" abysses. Coral-bearing areas within the Indian and Pacific Oceans are of vast extent, there being chains of archipelagos, 1,000 to 1,500 miles long. The reefs are rudely circular or elliptical in the islands but are linear along the coasts; in the one case, the reef encloses a lagoon, in the other, a lagoon-like channel separates the reef from the coast. These are fundamental elements of the problem, not one of which may be neglected in the solution. A clue to the explanation was found by this keen observer when he saw an islet of old rock, fringed with coral, rising from the lagoon of an atoll, so that the atoll-ring resembled in many respects the barrier reef of a continent and the lagoon itself resembled the lagoon-like channel seen on the Australian and other coasts.

Chamisso's suggestion that coral reefs had been formed on banks of sedimentary material seemed wholly incompetent to meet the conditions, for the areas are too vast, and Darwin was compelled to believe that the atolls rest on rocky bases; but even on this supposition, it appears incredible that peaks of several great mountain chains should all come to within less than 180 feet of the surface and that not one rose any higher. The long study in South America had prepared him to seek an explanation in mobility of the earth's crust; but it was clear that elevation could not bring about the conditions, as that would destroy the corals themselves; subsidence alone can account for the phenomena. And thus Darwin presents his case:

> If then the foundations of the many atolls were not uplifted into the requisite position, they must of necessity have subsided into it; and this at once solves every difficulty, for we may safely infer from the facts given in the last chapter, that during a subsidence the corals would be favorably circumstanced for building up their solid framework and reaching the surface, as island after island slowly disappeared. Thus areas of immense extent in the central and most profound parts of the oceans might become interspersed with coral islets, none of which would rise to greater height than that attained by detritus heaped up by the sea, and nevertheless they might all have been formed by corals which absolutely require for their growth a solid foundation within a few fathoms of the surface. . . . The rocky bases slowly and successively sank beneath the level of the sea, while corals continued to grow upward.

The origin of the ring as well as that of the barrier reef seemed to be easily explained by this hypothesis. The corals on the outer side of the reef grew with greater rapidity than did those within, as the supply of food is constant; those on the inner side became starved and eventually the interior growth ceased and the lagoon was shallowed by wind-drifted material from the shores.

Darwin's hypothesis and the facts on which it was based have become so familiar that students sometimes express surprise that so much praise has been awarded to the author. The conditions as presented in his discussion are so clear that certainly no man could reach any other conclusion. That is true, but it is true only because Darwin marshalled his facts in a manner so masterly; in any event, it is always easy to do a thing when another has done it well and told us how. But it must be remembered that an hypothesis of this sort, though normal enough in our day, was very abnormal in that day; indeed, it was contrary to Darwin's own underlying conceptions, for, though a uniformitarian, he had seen many phenomena which, for a time, made him only a halting disciple. Yet his hypothesis was a monumental contribution in support of the uniformitarian doctrine, which, under the leadership of Lyell, was gaining sturdy adherents. That the hypothesis met with uncompromising opposition need not be said. The material of coral origin extended to vast depths alongside of the islands, in some cases apparently to 4,000 feet. The upward growth of the reef was known to be extremely slow. If the subsidence and the upward growth kept pace, as was essential to the hypothesis, evidently the required period, belonging to the latest portion of the earth's existence, was immensely long. It is difficult now to understand how great moral courage was needed by the man who published such a doctrine; sixty years ago, the educated man of Great Britain had not learned to distinguish between faith and prejudice.

This effort to explain the origin of coral reefs has been regarded, justly, as Darwin's especial contribution to geology. It has been opposed strenuously by careful students during the last twenty years and even now it is a bone of contention; but the most strenuous opponent concedes that it is logical and a fair induction from the facts as then known. Be it true or not, be it a competent explanation or not, no matter. In influence on geology it has been as far-reaching as the doctrine of natural selection has been on biology. It involves every important problem in dynamics of the earth's crust; in testing it, men have been led into paths of investigation, which, but for Darwin, might still be untrodden. The influence went farther. The hypothesis was presented at a time when men's minds were warped by prejudice, when men were extremists, when too many were defenders of dogmas in science and too few were searchers after truth. Darwin's discussion was a model of frankness; suggestions offered by his predecessors were dealt with courteously; he searched far and wide for objections to his own suggestions, and when objections were found he stated them in detail, concealing nothing and urging further investigation. His conclusions were, for him, merely tabulations of observed facts. One can not overestimate the importance of this method; it was a chief factor in chang-

ing the tone of scientific literature, in leading to replacement of subjective by objective modes of investigation.

Darwin's work as geologist practically ended with these publications of the *Beagle* results. It is true that in later years he made some contributions possessing much interest, but they were merely incidental to studies in other directions; the greater part of his long life was devoted to biological problems. At the same time, his whole mode of thinking and of observing was that of the geologist, so that if one were treating of his later years the topic might well be the influence of geology upon Darwin. In his later works, one finds constantly recurring consideration of geological conditions as potent factors in biological change, while on the other hand he emphasized the influence of life as a factor in bringing about geological changes. To him nature was always one; and he, in great measure, was responsible for the broadness of view characterizing the geologists who were his contemporaries as well as for the remarkable change in attitude of the community toward scientific discussion. Nowadays, when workers are so many and knowledge is so increased, men have been forced into narrow lanes of investigation; students, perplexed by phenomena within their limited vision, too often think little and know less of what neighbors are doing. And this must continue until some important problems have been solved, at least in part, and some positive results have been obtained in many directions. Then another Darwin will come, will gather loose strands floating in the wind and will weave from them a new system, once more binding nature studies into one and providing a safe platform, whence men may start anew to fathom the unknown by means of the known.

DARWIN AND BOTANY[1]

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CONSIDERING the fact that Charles Darwin disclaimed the title of botanist, his contributions to the knowledge of plant life and its phenomena were certainly extraordinary. His investigations extended over a great range of topics, at one time or another practically covering the whole field of botanical research. In repeatedly stating that he was not a botanist, he evidently meant to imply that he was not a systematist, and it is true that his knowledge of plant taxonomy was the least of his scientific acquirements. In his first letter to Dr. Asa Gray, written in 1855, which was the commencement of a long correspondence, he almost apologized for asking questions! During that year he became keenly interested, however, in knowing more about the kinds of plants growing wild in the vicinity of his home, and in a letter to Dr. Hooker he complains about the dreadful difficulty of naming plants, though he apparently became quite enthusiastic in this pursuit and advised Dr. Hooker, "If ever you catch quite a beginner and want to give him a taste of botany tell him to make a perfect list of some little field or wood." The facts just stated seem to indicate the extent of his taxonomic studies. He accepted, for the most part, the names of plants which he studied from the determinations of others.

Darwin was attracted to observations of natural objects as a young boy and he early considered plants; his juvenile collections were entomological, and his earlier investigations were mainly zoological and geological. As a pupil of Professor Henslow at Cambridge University he attended botanical lectures and took part in field excursions; he greatly enjoyed the field work, and from it his inspiration for investigation was doubtless derived.

As naturalist of the voyage around the world of the ship *Beagle* (1831–1836) his collections of plants made in South America and on the islands of the Pacific Ocean, and his observations upon the botanical features of the countries visited, contributed greatly to the knowledge of the flora of those regions. They were extensively utilized by Dr. Hooker in his "Flora Antarctica" and in his "Flora of the Galapagos Archipelago," as well as by other authors in various contributions. Darwin's valuable herbarium is preserved in the museum of Cambridge

[1] An address given at the American Museum of Natural History on February 12.

University. That he collected assiduously at times during portions of this expedition, is evidenced by his having brought home specimens of 193 species of the 225 species which, after his specimens had been studied, were known to inhabit the Galapagos Islands and by the fact that about 100 species new to science were represented in his Galapagos collection. He noticed the extraordinary distribution of species or races on the several islands of this group, many of them inhabiting only a single island, and he laid the foundation for all subsequent study of insular floras. The narrative of observations and experiences during this memorable voyage is replete with interesting facts and suggestions concerning plants, and his conclusion that "Nothing can be more improving to a young naturalist than a journey in distant countries," is one that should be reiterated by all teachers of natural science, and such experience should be sought by all students who propose engaging in investigation. Darwin is commemorated in botanical taxonomy by many species named in his honor. The beautiful barberry, *Berberis Darwinii* of Hooker, native of Chiloe, is occasionally seen in cultivation. *Darwinia,* an Australian genus of the myrtle family, named by Rudge in 1813, commemorates his grandfather, Erasmus Darwin.

The beginnings of Darwin's theory of descent of animals and plants from preexistent species, with modifications, were made during the voyage of the *Beagle,* and from the year after his return to England, when, he tells us, he opened the first note-book on the subject. For twenty-two years he was interrogating gardeners and breeders, botanists and zoologists, and diligently observing plants and animals. He first thought of publishing on the theory of descent in 1839, but delayed for twenty years. During the studies which led up to the publication, in 1859, of "The Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life," Darwin closely observed a great number of wild and cultivated plants, with reference to variation in nature and under domestication, the struggle for existence due to competition for food and sunlight, the facts of geographic distribution, the succession of plant life on the earth as indicated by the fossils of successive geologic periods, and a great range of other facts and phenomena. The recorded observations of other botanists were also freely utilized and discussed. Nearly all the chapters of this epoch-making work contain conclusions drawn from his own botanical observations. He was especially impressed by the divergent views of different botanists relative to the taxonomic treatment of highly polymorphic genera such as *Hieracium* (hawk-weeds), *Rubus* (blackberry), *Quercus* and *Rosa,* and he employed this consideration to great advantage in his argument for derivation during descent. Rudimentary organs were considered with much interest and readily explained by Darwin as vestiges of structures which were useful to the plant in

earlier stages of its existence. The facts of geographic distribution were eagerly examined as bearing on the theory of descent and Darwin's writings abound in speculations relative to their significance. He was inclined to combat the geologic theory of former land connections of present existing continents, as not satisfactorily accounting for many features of geographic distribution, though he ultimately agreed with this theory to some extent. He closely studied the natural means by which seeds are transported over great distances and also inquired into the vitality of seeds.

The title of the "Origin" was a subject of considerable doubt in his mind, and in 1857, two years before it was printed, he had proposed to call it "Natural Selection." The title "Origin of Species by Means of Natural Selection," is, if taken literally, somewhat misleading, and has occasioned considerable discussion. The subtitle—"Or the Preservation of Favored Races in the Struggle for Life"—is a more accurate statement of his theory. On November 23, 1856, he wrote to Dr. Hooker:

> The formation of a strong variety, or species, I look at as almost wholly due to the selection of what may be incorrectly called chance variations. Again, the slight differences selected, by which a race or species is at last formed, stand, as I think can be shown in the far more important relation to its associates than to external conditions.

Darwin's great contribution to the subject of evolution was the incontrovertible proof adduced by him that living species are modified descendants of preexisting species, and that the modifications are brought about by natural causes. His observations led him to the conclusion that the modifications were all minute, gradual and cumulative. We know that they may also be considerable and abrupt and that they are cumulative because favorable changes are preserved.

How, then, do the modifications or primordial variations, either large or small, arise? Is variation an innate essential quality, or is it induced by external environmental factors? Proof of environmental agencies having at least something to do with it in plants seems to be accumulating, as the experimental work carried on by MacDougal and by Gager at the New York Botanical Garden appears to imply.

I think that we may now safely outline the methods of formation of species somewhat as follows: Through causes which are not yet at all well known, but by means of which agencies external to the germ-cells certainly may have a part, the offspring of a plant grown from seed differ more or less from the parent (variation). The thus modified offspring, subjected to natural selection, ultimately perish if they are unadapted, but survive if they are adapted to their surroundings. Repetitions of this process finally bring the descendants of plants to differ materially from their ancestors (evolution). The end of the

process seems to be the development of organisms which are little or not at all subject to variation (monotypic genera). All genera of plants containing a large number of species are evidently subject to continued variation and their species and races almost defy classification. Just what part the phenomena of hybridism take in the final result is not clear, but it may be pointed out that they are evidently unnecessary, because great groups, whole orders, in fact, of the fungi, are devoid of sexuality, and hybridism is therefore impossible among them; yet they are subject to variation like other plants and are quite as difficult to classify.

Observations on insectivorous plants occupied Darwin at intervals from 1860 until the publication of his volume on that subject in 1875. He commenced with the round-leaved sundew (*Drosera rotundifolia*) while staying at Ashdown Forest, and was soon intensely interested in the exquisite sensitiveness of the leaf-glands to nitrogenous substances. His studies were continued over most of the plants of the sundew family, and to others known to entrap insects or other small animals. He discovered that the leaves of *Drosera* and of *Dionæa* secreted a ferment when supplied with various kinds of nitrogenous food and he closely observed the movements of their glands and tentacles and recorded them in detail. Experiments were also made on these plants with a great variety of non-nitrogenous substances. Darwin pointed out the remarkable parallelism between the digestive powers of the secretions of the Droseraceæ and those of the gastric juices of animals. The sacs of the aquatic bladder-worts (*Utricularia*) and the leaves of butterworts (*Pinguicula*) were also closely studied. His book is replete with records of careful observations and ingenious deductions. *Nepenthes* had already been shown by Dr. Hooker to secrete digestive fluids in its pitcher-like leaves, and *Sarracenia* was suspected of similar activity by Darwin and by others, although he did not regard this as proved.

As early as 1838 or 1839 Darwin was attracted to observe the processes of pollination and noticed the dimorphic flowers of *Linum flavum*. He had concluded at that time that cross-fertilization was potent in holding species stable and constant. He obtained a great deal of information on this topic in 1841 by reading Sprengle's "Entdeckte Geheimniss der Natur," which stimulated him to continued investigations during summers and he became especially interested in the methods of pollination of the wild orchids growing about his home. This study of pollination of orchids resulted in the publication, in 1862, of his book on that subject, and in it his detailed observations are recorded. Some of his closest observational work was done on this subject of cross-pollination, and he examined a great many species and grew thousands of plants from seed, reaching the broad generalization that cross-fertilization is beneficial to a species and self-fertilization is

injurious. The phenomena do not now, however, appear to have as important a relation to evolution as they were formerly supposed to have, and Darwin later expressed regret that he had not given more attention to the processes of self-fertilization.

His interest in showing that cross-fertilization was beneficial led him to closely investigate the various structural features of flowers which necessitate this process to a greater or less degree, such as dicœcism, moncœcism, polygamy and heterostyly; his observations and speculations are presented in the volume entitled "Different Forms of Flowers and Plants of the Same Species," published in 1877. He records that making out the meaning of heterostyled flowers gave him very great pleasure. A chapter of the book is devoted to cleistogamic flowers, which are necessarily self-fertilized and produce seed abundantly. This work is largely a revision and rearrangement of several papers previously published in the *Journal of the Linnæan Society*.

"The Variation of Animals and Plants under Domestication," Darwin's largest work, appeared in 1868, published in two volumes. As bearing on this topic he had studied, among plants for many years, the cereal grains, garden vegetables, edible fruits, ornamental trees and ornamental flowers. In the preface he again discusses natural selection and defines it as "This preservation, during the battle for life of varieties which possess any advantage in structure, constitution or instinct," noting that Herbert Spencer had well termed the same process "The Survival of the Fittest." But the bulk of the work is given to the consideration of selection by man—artificial selection, by which races useful to us, economically or esthetically, have been preserved and modified, some of them having originated in very remote times and been taken advantage of by uncivilized man. A chapter is devoted to the phenomena of bud-variation, in which many cases of branches of plants different in one respect or another from other branches on the same plant are described in detail. Many of these have been taken advantage of by horticulturists for the propagation of valuable races. He did not reach any definite conclusion as to the cause of these interesting occurrences; but recently acquired knowledge of mutation seems to indicate that they are of that category, differing from seminal mutations in that a cell in the axil of a leaf is affected rather than a germ-cell. In these volumes we find Darwin's most detailed discussion of heredity of variability and of hybridism and the last chapter outlines his provisional hypothesis of Pangenesis, an ingenious supposition, applying to living matter the general features of the atomic theory, with an additional inherent power of reproduction of the atoms or "gemmules" as he termed the hypothetical ultimate particles.

The movements of plants and of their various organs were also studied by Darwin for many years. His first essay on this topic

appeared in 1865 and ten years later he revised and enlarged it as a book under the title "The Movements and Habits of Climbing Plants," using, as always, not only his own detailed and extensive observations, but also the published writings of other botanists, among them the paper on tendrils by Hugo de Vries, who was subsequently destined to throw such a flood of light on the phenomena of variation. Darwin grouped climbing plants into twiners, leaf-climbers, tendril-bearers, hook-climbers and root-climbers. He maintained that the climbing habit has been developed to enable vines to reach the light and free air; tropical forests show conclusively that this is the case. He showed that circumnutation, the bending of growing tips successively to all points of the compass, is a general phenomenon among flowering plants, and he thought it of high importance to them. The sensitiveness of tendrils to external influences interested him deeply and he made many original experiments upon them. Following the subject much further, he published in 1880 the work entitled "The Power of Movement in Plants," a treatise abounding in records of original observations on seedlings and parts of mature plants, including further studies of circumnutation, of the sensitiveness of plants to light and to other forces, and of the phenomena of geotropism and apogeotropism, which he regarded as modified phenomena of circumnutation.

The value of the impulse given by Darwin to botanical investigation in all its branches is beyond estimation; his power of exact observation and record has seldom been equaled and certainly never excelled; his deductions were highly philosophical and most of them have stood the test of thirty years' inquiry and criticism; he was searching for truth and his absolute honesty in research is plainly evidenced by his repeated criticism of his own conclusions.

The immense number of plant species which had been described and named, and the lack of any complete index to them led Darwin to provide in his will for complete enumeration of the names of published species of flowering plants. This great work was prepared at the library of the Royal Gardens, Kew, England, and published in 1895 in four large quarto volumes, to which several supplements have since been added. This "Index Kewensis" is a great boon to all investigators, and is quite indispensable to those who have to take plant names into consideration.

DARWIN AND ZOOLOGY[1]

By Dr. HERMON C. BUMPUS
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THIS is an assembly composed substantially of members and friends of the New York Academy of Sciences, united to do homage to one whose genius has been long felt in our meetings, and whose influence is now recognized in every field of intellectual endeavor. The example of Darwin's precision in observing, of his wisdom in interpreting, and of his truthfulness in recording the phenomena of nature, has transformed zoology—the subject assigned to me—from prosaic description to acute speculation, from a merely interesting study to an aggressive science.

This change has taken place in an incredibly short space of time, and it may be worth while, on an occasion such as this, to examine the condition of scientific academies and similar organizations in America at the time of the publication of the "Origin of Species," to note the first center of appreciative acceptance and to trace the spread of the belief in Darwinism as it betrayed itself in the publications of the time.

Fifty years ago there were in America five leading centers of organized scientific activity.

In Philadelphia were the American Philosopical Society, founded by Franklin, and then well along in its second century of "promoting useful knowledge," and the Academy of Natural Sciences, approaching its semi-centennial.

In Boston were the adolescent Boston Society of Natural History, approaching its thirtieth birthday, and the mature American Academy of Arts and Sciences, founded in 1780.

In New Haven was the Connecticut Academy, founded in 1786.

In Washington, although the National Institution for the Promotion of Science (founded in 1840) and the Smithsonian Institution had been publishing for eleven years, men of science apparently did not unite in an academic way until the Philosophical Society of Washington was organized in 1871. Even the National Academy was not incorporated until 1863, four years after the announcement of the "Origin of Species."

In New York, this academy (then called the Lyceum of Natural History) was meeting at Fourteenth Street, at a point now occupied by the headquarters of Tammany Hall. Of those then attending its meetings, but one now remains.

[1] An address given at the American Museum of Natural History on February 12.

The dominant mind at Philadelphia was that of Leidy, thirty-six years of age. Cope was a boy of nineteen. In Washington, were Joseph Henry, sixty-two; Bache, sixty-three; Baird, thirty-six, and others attached to the Smithsonian Institution, and the great government surveys. Baird was often a contributor to the publications of the New York Lyceum of Natural History.

In New York was Torrey, a man of sixty-three, and among others two young men, Theodore Nicholas Gill—the senior member of this academy—and Daniel Giraud Elliot, now honoring this museum with his presence—both born in New York, and both in their early twenties. Not only have these two—early identified with the scientific publications of this academy—witnessed the change that has taken place during the past fifty years, but their long series of contributions to science admirably illustrate the strange power that has been exerted upon zoological work in general, and descriptive zoology in particular, by him who came into being one hundred years ago.

In New Haven were James Dwight Dana, forty-six; Daniel C. Gilman, twenty-eight, and the Sillimans.

In Boston, were Agassiz, adored by the people—preeminent among teachers—the studious lovable Gray, at one time (1836) librarian of this academy, and Jeffries Wyman. Both Agassiz and Gray were about the age of Darwin. Jeffries Wyman was a few years their junior; of him Lowell has written:

> He widened knowledge and escaped the praise
> . . . . . .
> He toiled for science, not to draw men's gaze.

Under the influence of these, Agassiz, Gray, Jeffries Wyman, there gathered at Cambridge, at about this time, what we should now informally and affectionately call "a bunch of boys." Shaler, eighteen; Verrill (who has come down from New Haven to be with us this afternoon) and Packard, twenty; Morse, Hyatt and Allen—our Dr. Allen—twenty-one; Scudder, twenty-two.

Of the five centers of scientific activity, youth was certainly the characteristic of the school at Boston. It is therefore safe to predict that the germ of the new truth in biological science would find a more favorable medium in Boston than here in New York or farther south.

The infection was immediate, indeed "*pre*-immediate." The period of incubation extended over about ten years, ending in an acute epidemic from 1871–1876, which affected lyceums, associations and academies indiscriminately. Convalescence than began, since which the American body-scientific has enjoyed good health and has shown many periods of remarkable growth.

The "Origin of Species" was published in London late in November, 1859. The following month, Asa Gray, long intimately acquainted with Darwin, and anxious that Americans should see promptly the

significance of the new theory, wrote for *Silliman's Journal* a review of the book, before a single copy of the "Origin" had reached this country. He predicted that the work would produce great discussion—it did. A copy arrived, it was carefully reviewed, but before the review could be gotten through the press, a second edition was announced, and within three months two American editions were advertised.

Gray gave his first review in December. In January, Professors Agassiz, Parsons and Rogers are recorded as having discussed the "Origin and Distribution of Species" at a meeting of the American Academy of Arts and Sciences on Beacon Street. Gray was present. In February Agassiz began his open opposition to the theory of Darwin, stating at the Boston Society of Natural History that, while Darwin was one of the best naturalists in England, his great knowledge and experience had been brought to the support of an ingenious but fanciful theory.

In March Agassiz continued to oppose Darwin, and in April Gray and Parsons made their reply. In May they were at it again. Then followed the admirable essay of Parsons, Professor of Law at Harvard, and the unfortunate advance sheets of the third volume of Agassiz's "Contributions." Then came Gray's *Atlantic Monthly* articles, and thus ended the first year.

Among the records of the learned societies of New York, Philadelphia and Washington, I can find nothing to indicate that there was any particular interest in the disturbances that were going on in and about Boston. Professor Dana, easily the dominant figure in science at New Haven, was in poor health and out of the country, but it was generally considered that his intensely idealistic views would probably have prevented him from accepting a theory that was felt by many to be grossly materialistic. The infection therefore was local and remained local about Boston for a full decade.

In 1863 Jeffries Wyman, in his review of Owen's monograph on the "Aye-aye" gave inference of his adherence to the theories of Darwin, and indicated the impossibility of there being any neutral ground.

In 1864 Agassiz doubtless discussed the matter before the National Academy in a paper on the "Individuality of Animals." A copy of the paper I have been unable to find.

In 1865 Morse came to New York, from Salem, to be the guest of this academy, but the formal paper that he presented did not contain even a remote allusion to the discussions that were going on in what was then considered America's educational center.

In 1867 Hyatt's paper on "Parallelism" appeared. This I believe to be the first distinctly evolutionary contribution from the zoological side. In this year, 1867, Professor Newberry, later and for twenty-three years the president of this academy, delivered his address at the Burlington meeting of the American Association for the Advancement of Science, betraying in this a singular nobleness of character toward

those to whose advanced views he felt that the scientific world could not entirely subscribe, and admirably illustrating what he interpreted to be the prevailing opinion, as shown by the following quotation:

> Although this Darwinian hypothesis is looked upon by many as striking at the root of all vital faith, and is the *bête noire* of all those good men who deplore and condemn the materialistic tendency of modern science, still the purity of life of the author of the "Origin of Species," his enthusiastic devotion to the study of truth, the industry and acumen which have marked his researches, the candor and caution with which his suggestions have been made, all combine to render the obloquy and scorn with which they have been received in many quarters, peculiarly unjust and in bad taste.

This was also the first year of the *American Naturalist,* edited by those four pupils of Agassiz—Packard, Morse, Hyatt and Putnam—of whom two are still spared. The introduction of the charming first volume of this characteristic American publication is sufficient proof that at the time of its issue even the younger men felt that there were two distinct schools of thought relative to the "Origin of Species"—Those who are familiar with this introduction will remember that it is illuminated with one of Morse's inimitable sketches, a snail peering through a binocular microscope, symbolical, doubtless, of the slowness of perception of those who clung to this archaic instrument and possibly also of those who cling to archaic ideas.

The following year, 1868, the Academy of Natural Sciences of Philadelphia, which in 1860 had elected Darwin to membership, published the first important direct contribution to the subject of evolution made by one not directly under the influence of the Boston academies. This contribution, "On the Origin of Genera," was made by Cope, who for several years had been submitting papers to the academy of a descriptive and semi-speculative character, and largely dealing with the classification of reptiles. I believe that I am perfectly safe in saying that no academy in America has ever published a paper that reflects more to its credit than this extraordinary essay of Cope. It is apologetically issued as a fragment, but in it there are shown an intimate acquaintance with anatomical detail that is almost supernatural, an independence of thought that is extraordinary, a power of analysis that stuns the reader, an estimate of the weak and the strong points of the Darwinism theory that is masterly, an agility of logic that marks its author as a dangerous antagonist, an energy to reach the truth, and an impetuosity to convince others of truth, that is prophetic, indeed, that is completely demonstrative of pent-up mental power, which must have been most disturbing to those of his academy who had nestled down into positions of comfortable intellectuality.

We now enter upon the five years of acute activity.

On December 15, 1871, Cope attended a meeting of the American Philosophical Society, and presented his paper on "The Method of Creation of Organic Forms." In a fortnight a reply was given, which began with a quotation from Job: "I am a brother to dragons and a

companion to owls," and continued for several pages in attempted explanation and demonstration of the falsity of Darwin's theories, and ended with the author's conviction that the only good that can come from these theories is the fact that they must bring about their own defeat.

Cope replied immediately and was then replied to, and so on. But why follow the discussion?

The spell was being felt even farther south. Within two months of the date of its founding, the Philosophical Society of Washington listened to a paper by Professor Gill, in which it was stated that if the doctrine of evolution was accepted at all, it must involve man.

This was also the date of Dr. Allen's paper on the "Geographical Variation of North American Birds," a philosophical as well as a descriptive article, an important contribution to the then scant literature of distribution, a paper which established a distinct method of zoological research that has reflected the highest credit on its author and on the institutions with which he has been connected.

It was also in this year that Morse published his paper on "Adaptive Coloration."

In January, 1872, the New York Academy made its first direct contribution to the subject of evolution by publishing a brief paper on the "Carpus and Tarsus of Birds." I hope that Professor Morse, now forty-five years a member of this academy, is present at this gathering, for the fifty years that have passed since the appearance of the "Origin of Species" exactly synchronize with the period of his devotion to the principles enunciated therein.

If, among the volumes of this academy from 1859–1876, one binding shows more signs of use than the others, take down the book, and you will find that it opens to this article by Professor Morse: a contribution to zoology, to comparative anatomy, to embryology, and to the theory of evolution. It is a refreshing spot, but somewhat out of place in an arid expanse of descriptions of new species and revised classifications.

Another paper issued by the academy in 1872, and characteristic of the new thought of the time, was by Benj. M. Martin on the "Unity of the General Forces of Nature," but this was physical rather than biological.

If one were forced to accept the presidential addresses of the American Association for the Advancement of Science as indicative of the advancement of science in American associations, the address of 1873, delivered by one who said he thought that natural selection had died with Lamarck, would sadly mislead. He writes:

> In Darwin we have one of those philosophers whose great knowledge of animal and vegetable life is transcended only by his imagination. In fact, he is to be regarded more as a metaphysician with a highly-wrought imagination than as a scientist.

But this is only the beginning of the gloom that anticipated the dawn.

Although in 1874 Dr. Elsberg, in a "Contribution to the Doctrine of Evolution," addressed this academy (and also the American Association for the Advancement of Science), in favor of the principles of Darwin, although Cope continued to sustain his earlier contentions, and general workers were beginning to make original observations in favor of the principles of organic descent, the reviewers of the deliberations of scientific gatherings give little promise of anything like a general acceptance of the beliefs in which we are interested.

In 1875, the retiring president of the American Association said:

> I fear that the unhappy spirit of contention still survives, and that there are a few who fight for victory rather than for the truth.

One of the vice-presidents at this meeting declined to "enter on the vast field of discussion . . . opened up by Darwin and others," and resolved to avoid the use of the word "evolution," "as this has recently been employed in so many senses as to have become nearly useless for any scientific purpose."

Thus closed five years of struggle.

The year 1876, the centennial of political independence in America, marked also the dawn of intellectual independence and scientific freedom. It was the year of Brooks's first Salpa paper, and of his paper on pangenesis. Cope explicitly stated that the law of natural selection was now generally accepted, and the then librarian of this academy, Louis Elsberg, submitted his paper on the plastidule hypothesis, as nonchalantly as though he were discussing a lingual ribbon.

It was under these really blessed conditions that the American Association met in Buffalo and listened to a vice-presidential address fully worthy the title of the organization. Edward S. Morse had demonstrated his ability as an investigator in his paper of 1872, already mentioned, but the simple, straightforward, patient and kindly manner in which he addressed his audience in 1876, the thoroughness with which he scanned the work of others, the fairness with which he acknowledged the value of their results, and his concluding passages, in which he indicated the important bearing that the theories of descent had upon the social problems of the day, render his address a fit conclusion of a distinct epoch in the history of American science.

Since 1876, practically every zoological worker has sought to make some contribution that might strengthen his faith in a rational evolution of organic life and activities. It may be that such contributions will prove insufficient. It may be that Darwinism as a *thing* will ultimately fail of proof, but to those in the future who may inquire for the reason for these exercises and for the erection of this monument, ***Darwinism as a method*** will ever be a sufficient reply.

FOR DARWIN[1]

By Professor T. H. MORGAN
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WE have come together to-day to consider Darwin's influence on zoology. It is a hazardous task to pretend to estimate the influence of any event on the course of history so long as we can not know what the outcome had been otherwise. But to this at least we can testify, that it is the general belief of zoologists to-day that Darwin's influence in bringing about the acceptance of the theory of evolution marks a turning point in the history of their science, and I shall attempt to justify this opinion by pointing out the condition of zoology before Darwin and its subsequent course of development after 1859.

To the zoologist Darwin was above all else a zoologist. It is true he interested himself greatly in geology, but he does not stand as a leader of that science; he carried out many experiments with plants and wrote some important botanical books, and here the zoologist will yield second place to his brother, the botanist. Darwin wrote on the "Descent of Man," he studied the expression of the emotions and carried out physiological work along several lines, yet I should not rank him preeminently an anthropologist, a psychologist or a physiologist any more than a paleontologist or a botanist.

In the mind of the general public Darwinism stands to-day for evolution. The establishment of the theory of evolution is generally accepted as Darwin's chief contribution to human thought, and while Darwin did not originate this idea that forms the framework of our modern thinking, yet by general accord its acceptance is attributable, and justly so, to Darwin.

To the zoologist Darwinism means more especially evolution accounted for by the theory of natural selection, yet also many other things, to which I shall refer in the proper place.

But I shall attempt this afternoon, before all else, to convince you that the loyalty that every man of science feels towards Darwin is something greater than any special theory. I shall call it the spirit of Darwinism, the point of view, the method, the procedure, of Darwin.

In order that we may form some idea of Darwin's influence on zoology, let us examine the condition of that science prior to 1859 to

[1] A lecture on "Darwin's Influence on Zoology," delivered at Columbia University, February 26, 1909.

see what influence zoology had on Darwin and his contemporaries. I shall not try your patience by attempting to review the history of the subject, but it would not belittle the greatness of Darwin's achievement one whit to find that brilliant discoveries had been made before his time, the theory of evolution plainly enunciated, the doctrine of spontaneous generation disproved; comparative anatomy widely studied; the important functions of the body elucidated, the foundations of the science of embryology laid, and the principles of pedigree breeding followed.

In the eighteenth century, when the study of different kinds of animals inhabiting sea and land attracted the attention of zoologists, great classifications were invented. Two main facts emerged. On the assumption of fixity of type, a classification of the different forms of animals and plants became possible. But on the other hand the more extensive the material to be classified, the more difficult it became to make such systems, for the fixity of type was often lost in apparent transitions to other types. Counter claims arose as to the superiority of one system over another, and the question of an artificial system versus a natural one was widely debated. Now, an artificial system, like the arrangement of the words in a dictionary, is obviously only a matter of convenience, but it became a question of deep philosophical importance to decide what was meant by a natural classification. To us at the present time a natural classification implies a relation due to descent; it is neither more nor less than the natural relation of a man to his ancestors. But it were a fatal mistake to read our meaning backwards to the time before Darwin.

To the great Cuvier a natural system meant an assemblage of groups having a common plan of structure, and he was enraged by Geoffroy St. Hilaire's attempt to put all animals from the bottom to the top in a straight line. A common plan of structure might only mean that idea which best expressed the outcome of a wide study of structure; but to those who tried to peer behind the scenes it meant not seldom to fathom the creation of the world; and it required no vivid imagination to add that it gives an insight into the plan by which the world was created.

A historian of the times wrote:

> Yet in fact the assumption of an end or purpose in the structure of organized beings appears to be an intellectual habit, which no efforts can cast off. It has prevailed from the earliest to the latest ages of zoological research, appears to be fastened upon us alike by our ignorance and our knowledge . . . and the doctrine of unity of plan of all animals, and the other principles associated with this doctrine, so far as they exclude the conviction of an intelligible scheme and a discernible end, in the organization of animals, appear to be utterly erroneous.

Contrast, in passing, this pious conviction with Geoffroy's modest lines:

I ascribe no intention to God, for I mistrust the feeble powers of my reason. I observe facts merely and go on. I can not make nature an intelligent being who does nothing in vain, who acts by the shortest mode, who does all for the best.

Thus arose in the eighteenth and nineteenth centuries the dogma of the fixity of species—a dogma based, it is true, on a direct appeal to fact as well as to conscience. But this dogma contained the germ of its own undoing, in so far as it appealed for its support to observations that every man might make for himself. Yet so influential were its advocates, so convinced of its truth, that more than one assault was made before it crumbled away.

It is no small pleasure to repeat to-day the names of those bold and original thinkers, who braved the displeasure of their compatriots and the contempt of their times, who brought forward evidence and argument to disprove the teaching of the schools. Their work, it is true, failed in the sense that it received no sufficient meed of praise or word of commendation, but who will deny that a seed was sown that in time bore fruit? Foremost, I think, ranks the great Lamarck, the centenary of whose "Philosophie Zoologique" is celebrated this year in France—a bold spirit, whose ideas, based on a wide familiarity with facts, live and bear fruit to-day. Geoffroy St. Hilaire, advanced thinker and philosopher of nature, opponent of the great anatomist Cuvier, brought the problem of evolution to the bar of judgment, losing the decision, it is true, but his ideas a later generation hold in high esteem. Erasmus Darwin, grandfather of our Darwin, author of "The Zoonomia," celebrated in verse "The Botanic Garden" and the "Loves of the Plants," and even before Lamarck, advocated the principle of evolution and the thory of inheritance of acquired characters. Herbert Spencer, adopting the idea of evolution, laid thereon the elaborate superstructure of his philosophy. Robert Chambers, too, kept alive the central idea of change in the organic world in his "Vestiges of Creation." Others there were, besides, in different lands, but these especially were nearer to Darwin and his times.

We come now to the years between 1837 and 1844, when Darwin was making his memorable notes on the relation between varieties and species. Reading through his letters of this period one is surprised to find how little he was impressed by the history of zoology and the influences of his own time, and how much he based his conclusions on the results of his own close observations, his accumulation of data, and careful consideration of facts. In regard to Lamarck, Darwin states in his autobiography, that in 1825 when he was at Edinburgh University, Dr. Grant "burst forth in high admiration of Lamarck and his views on evolution. I listened in silent astonishment, and as far as I can judge, without any effect on my mind."

In later years, after reading Lamarck, Darwin wrote Lyell, in 1859:

You often allude to Lamarck's work; I do not know what you think about it, but it appeared to me extremely poor; I got not one fact or idea from it.

Writing to Lyell in 1863, he says:

You refer repeatedly to my view as a modification of Lamarck's doctrine of development and progress. . . . Plato, Buffon, my grandfather before Lamarck, and others, propounded the *obvious* views that if species were not created separately they must have come from other species, and I can see nothing else in common between the "Origin" [of Species] and Lamarck.

Darwin wrote to Hooker in 1844:

Heaven forfend me from Lamarck's nonsense of a "tendency to progression," "adaptations from the slow willing of animals," etc. But the conclusions I am led to are not widely different from his; though the means of change are wholly so.

Darwin had read "The Zoonomia" of his grandfather prior to 1825 in which "similar views [to those of Lamarck] are mentioned but without producing any effect" on him. He continues, with his usual candor:

Nevertheless it is probable that the hearing rather early in life such views maintained and praised may have favored my upholding them under a different form in my "Origin of Species."

It is a regrettable fact that Darwin did not appreciate Lamarck's work. The failure of Lamarck's writings to produce any apparent influence on Darwin may be attributed, I think, to the form in which Lamarck's views are presented. He uses facts as illustrations of his ideas, while with Darwin the facts are all important as furnishing the evidence on which a theory is to be established. He misunderstood Lamarck's view in regard to the inheritance of acquired characters, yet held himself the same opinion in the main as had Lamarck. The modern idea of descent, as a system of branching due to *divergence* in those species descended from the same parent species, was expounded luminously by Lamarck, yet Darwin discovered it independently for himself. He says:

But at that time (1844) I overlooked one problem of great importance; and it is astonishing to me . . . how I could have overlooked it and its solution. This problem is the tendency in organic beings descended from the same stock to diverge greatly in character as they become modified. That they have diverged greatly is obvious from the manner in which species of all kinds can be classed under genera, genera under families, families under suborders, and so forth, and I can remember the very spot in the road where to my joy the solution occurred to me.

It is this same view that Lamarck had fully expounded thirty-five years before.

We have now arrived at the period just before the publication of Darwin's famous book. It is sometimes said that the time was ripe for the reception of the ideas formulated by Darwin—it was in the air,

as we say—but if so, it must have been so attenuated as to be invisible to eyes as sharp as Huxley's and the other famous naturalists of that time. Huxley says that within the ranks of the biologists he met with but one who had a word to say for evolution. Outside these ranks the only person known to him "whose knowledge and capacity compelled respect" and who advocated evolution was Herbert Spencer. "Many and prolonged were the battles they fought" on this topic, but Huxley maintained his agnostic position. He states:

> I took my stand upon two grounds; firstly that up to that time the evidence in favor of transmutation was wholly insufficient; and secondly that no suggestion respecting the causes of the transmutation assumed which had been made was in any way adequate to explain the phenomena. Looking back at the state of knowledge at that time I really do not see that any other conclusion was justified.

This frank statement of Huxley not only gives us an insight into the position of one of the most progressive zoologists of that time, but what is of more importance it implies also *why* the "Origin of Species" convinced him of the doctrine of evolution.

We have now sufficiently traced the possible influences of the times on Darwin. Before we proceed to study the influence of Darwin on his time, let us for a moment pause to consider what influence Darwin's own surroundings had in shaping his views. His voyage in the *Beagle* had brought him in contact with the question of geographical distribution. He read Malthus in 1838 and this gave him his first idea of the survival of the fittest; and, as his son and biographer states, this date marks "the turning point in the formation of his theory," so that by 1844 he formulated "a surprisingly complete presentation of the argument afterwards familiar to us in the 'Origin of Species.'" His extensive study of variation under domestication furnished him with the experimental evidence that went so far towards making his study of variation of far-reaching and profound importance. Indeed, in this one essential respect, Darwin was far ahead of all of his contemporaries, and, if you will pardon the anachronism, far ahead of his successors. It is only in recent years that zoologists and botanists have begun once more to work the rich mine of materials at their very doors. The paper of Wallace on "Natural Selection" in 1858, the reception to the "Origin of Species" in 1859, the storm of disapproval it met on the one hand, the staunch and able friends it made on the other, need only be recalled in passing.

We come now to the influence that Darwin's work has had on modern zoology. That influence is due not alone to the "Origin of Species" that gave to the world an abstract only of his views, but equally to his other works, especially, I think, the "Variation of Animals and Plants under Domestication," and the "Descent of Man." After Darwin and largely as an outgrowth of the wide interest his views aroused in all

branches of zoology we find activity going on in many lines of work. One group of workers, the systematists, have kept nearer, I think, to the older traditions. They have been concerned with three of the most important matters that have a direct influence on the "Origin of Species"—the intensive study of species and varieties, the geographical and geological distribution of animals, and the influence of the environment in modifying species. Their results have supplied the most extensive contributions, perhaps, that have been made to the theory of species-formation and transmutation. They seem to me, however, to have paid less attention to another, equally important, field, that of the adaptation of animals to their environment, and the causes that have been effective in bringing about this adaptation. To physiology we look in vain for an answer to this question, that is perhaps a physiological problem, for while physiology has advanced to a wonderful degree our knowledge of the complicated adjustments within the body, the origin in time of these adjustments and their relation to the outer world has excited less interest.

The morphologists, or philosophical anatomists, form the second great group of students whose activity is a direct outgrowth of Darwinism. The determination of the relationships of the great classes of animals on the principle of descent has occupied much of their time. Two other important fields of labor have also fallen to their share. The study of development or embryology has been almost exclusively pursued by morphologists, inspired in large part by the theory of recapitulation.

The older form of the doctrine, that in the development of the individual the past history of the race is repeated, has been revived—a doctrine much in vogue in the early part of the last century, which has continued to have its followers despite the different interpretation that von Baer gave to the same facts. Whatever interpretation we choose at the present time, the presence of structures like gill-slits in the human embryo, directly comparable to those in the fish, has had an important influence in disentangling the relationship of living animals to their remote ancestors.

The morphologist has also undertaken the study of heredity, and the relation of heredity to the germ-cells that are the links in the chain of organic life. Few other studies have advanced in recent years at a more rapid pace and few have yielded facts of greater significance, for here lies the key to the origin and nature of variations.

Systematists and morphologists alike have been evolutionists, but it is a curious fact of zoological history that until very recently there has been no body of students whose interests have been directed *primarily* towards the problems of evolution. This is due, I think, to a general feeling that the data for evolution are rather the by-products of the zoologist's work-shop, than products directly manufactured by him,

despite the splendid example of Darwin to the contrary. Is it not strange, therefore, with all the real interest in the theory of evolution, that so few of the immediate followers of Darwin devoted themselves exclusively to a study of that process? As I have said, the systematists have been accumulating a vast amount of valuable material, but their chief interest has, on the whole, been in its classification, only secondarily in its bearing on evolution. The morphologist has been busy in *applying* the theory of evolution to the explanation of group relationships. The paleontologist has perhaps been more directly concerned with the evolution question than has any other worker.

There is a school that calls itself Lamarckian or Neo-Lamarckian which as far as its name goes should include the followers of Lamarck rather than of Darwin. Yet with few exceptions the Neo-Lamarckians derive their inspiration, I think, directly from Darwin. Darwin held that characters acquired during the life-time of the individual may be transmitted to the offspring. He abhorred what he supposed to be Lamarck's rubbish, that an animal acquired a new part by willing it. We have seen that this is a travesty on Lamarck's real teaching, and that on the whole Darwin's view of acquired characters is almost Lamarck's. Yet the modern Lamarckians get their doctrine direct from Darwin rather than from Lamarck, who propounded it fifty years earlier, as had Erasmus Darwin, still earlier.

I have laid emphasis on the relation of Lamarckism to Darwinism in order to draw attention to the problem of adaptation. The Neo-Lamarckians have kept this all-important question in the foreground, while others have taken adaptation too much for granted in their attempts to explain the origin of species; for species, in a technical sense, may have little to do with the problem of adaptation. The life of an animal is intimately dependent on its adaptative characters, but its "specific characters" may be largely unimportant for its existence.

Systematists and morphologists include broadly the followers of Darwin during the thirty years after the publication of the "Origin of Species." They have advanced to a high degree the principles of their science, and the modern aspect of zoology is largely the outcome of their varied and far-reaching labors.

There is a small group of writers scattered amongst these larger groups that are ranked or rank themselves Neo-Darwinians. I must pause a moment to pay them my tardy respects. They have set themselves up to be the true Darwinians. They seem less concerned with the advancement of the study of evolution than with expounding Darwinism as dogma. Their credulity is more remarkable than their judgment. To *imagine* a use for an organ is for them equivalent to *explaining* its origin by natural selection without further inquiry. Any examination, in fact, into the nature of variation, they appear to

regard as superfluous, although harmless, but it is heresy to study critically the working out of the theory of natural selection. Such has ever been the procedure of the infertile followers of great leaders. In the present instance the result is the more deplorable, since Darwin's own independence of the traditions of all schools, his careful study of facts, his emancipation from prejudice, are his lasting virtues. The Neo-Darwinian, worshipping the letter of the law, forgets its import. Let us salute, and pass.

And now we come to the last twenty years of zoology as influenced by Darwin. This, I believe, is the brightest chapter of Darwinism, for the spirit of Darwin is once more abroad.

Foremost amongst the many debts that modern zoology owes to Darwin is this: he pointed out that in order to understand how evolution takes place, we must study the variations of animals and plants, for here is the material on which rests any solid superstructure. To my mind, the appreciation of this maxim and its application is the distinguishing feature of Darwin's work. Before his time the theory of evolution remained but a general idea, though one of profound significance. After Darwin, the theory of evolution rested its claims for recognition on a definite body of information relating to variations and their inheritance. It is these data that first convinced his greatest contemporaries of the reality of evolution, and finally convinced also the rank and file of thinking men. So extensive were the facts of variation accumulated by Darwin, so penetrating was his analysis of these facts, so keen was his insight, and so wise his judgment as to their meaning, that for thirty years afterwards little of importance in this direction was added. In their amazement at Darwin's accomplishment zoologists forgot that he had opened the door leading into an unexplored territory. During the last twenty years the march forward has once more begun and the reward has been immediate.

Let us tarry therefore a little in these rich and pleasant fields of discovery and examine in some detail what is being done. The study of variation has been actively pursued in three main directions. The biometricians have applied exact measurements to variation; the ecologists have studied the complex influences of the environment; the experimentalist has put to the test the supposed factors of change. Each of these methods has brought out results of significance.

A careful study of variations within each species has shown that taken as a group many variations conform to the law of probability. Popularly expressed, this means that chance determines variations, or, put more exactly, variations taken as a group and measured, give the same mathematical results that follow when any set of objects become arranged according to the laws of probability. There was a time when chance meant lack of conformity to law. Such a popular interpreta-

tion has no scientific standing. The great law of causation is not abrogated, but the outcome is only the result of a large number of small influences whose effects depend on the nature of the material and on the nature of the conditions. It is so important that this fact be clearly understood that I may be pardoned if I call to mind some familiar illustrations. No two leaves on a tree are identical, yet if many are measured, they give the curve of probability. Men are of different heights, yet they range about a mode. Color appears in various shades, yet if standardized, it is found to follow the same laws of chance variation.

What value have these facts for the theory of evolution? If in every generation we find that the same kinds of individuals recur, the results mean stability, not progress. That this state of affairs actually exists in many species living under the same environment during successive generations there can be little doubt. But change the environment and the results also change. Another factor comes to light that is independent of outside conditions. It is what has been called preferential mating. If within a group the males and females of certain kinds tend more often to pair with each other, the collective group becomes modified in one or more directions. In man this factor assumes a special importance, for, as Pearson has shown, there is measurable evidence that such mating occurs.

It has often been urged, and I think with much justification, that the selection of individual, or fluctuating variations could never produce anything new, since they never transgress the limits of their species, even after the most rigorous selection—at least the best evidence that we have at present *seems* to point in this direction. But a new situation has arisen. There are variations within the limits of Linnean species that are definite and inherited, and there is more than a suspicion that by their presence the possibility is assured of further definite variation in the same direction which may further and further transcend the limits of the first steps. If this point can be established beyond dispute, we shall have met one of the most serious criticisms of the theory of natural selection.

It is not without interest to note in this connection that Darwin often assumed that *fluctuating variations* are transmitted to the offspring. The idea that they are not was a later development—the result, it is true, of a better knowledge of the law of fortuitous effects, or of probability. But we have discovered the additional fact that *some small* variations are inherited. Let us call these *definite variations,* and if these be the material with which evolution is concerned, Darwin's assumption in regard to the nature of variation will be, in part, justified.

These small, definite variations appear to be closely allied to those larger, more visible definite variations that we now call mutations.

We owe our modern ideas of such variations mainly to de Vries and to those who have followed in his footsteps. Such sudden changes have been long known and were spoken of by Darwin as saltations—or sports. Darwin knew of cases like the ancon ram, from which a race of short-legged sheep was produced. He knew that totally black or melanistic mutations and albinos arise in many groups suddenly, and transmit their characters. A black-shouldered or japanned peacock has appeared more than once and perpetuated itself without selection. It would be out of place to-day to discuss this absorbing problem. That extreme mutations may at times have been an element of progress in nature few will deny, especially if we exclude such monstrous forms as those the breeder has used in building up domesticated races of animals.

It is not, however, to these extreme examples of definite variations that I wish especially to draw your attention, but to that group of smaller variations of a similar nature that may at their first appearance fall within the limits of ordinary variability. I now ask you, therefore, to follow me in an attempt to apply this latest discovery to the theory of evolution.

If we trace the ancestors of any living animal—man, for example—we discover that his ancestry goes back not as a single line, nor as a converging system of lines, but as a vast branching network. Each man has had 2 parents, 4 grandparents, 8 great-grandparents, 16 in the fourth generation, 32 in the fifth, 64 in the sixth, 128 in the seventh, 256 in the eighth, 512 in the ninth, 1,024 in the tenth. A few generations further removed we should expect to find that the majority of all the individuals of the species had poured their blood, as we say, into each individual of the future generations. Each of us is the descendant of a large population. The statement is not strictly true, for some lines die out, many lines cross, and caste has narrowed the field, but the statement suffices to show that a species moves along as a horde rather than as the offspring of a few individuals in each generation. The mass serves to keep the species afloat in times of calamity, it may have little else to do directly with its advance. Nevertheless this fundamental fact is too often overlooked in the attempt to explain the origin of new races, varieties and species from single favorable variations.

For *advance* we must look to those individuals that contribute something new to the species—it is the superman that will add something to the common level of humanity, but the rest keep the race alive until his advent and then carry his kind forward on an advancing wave.

If we could count those individuals that are the pioneers of advance, their number might be very small; in order to survive, they must graft themselves onto the stock. They are the harbingers of the better times to come—the forerunners of progress.

We touch here the crucial point of evolution in its relation to Darwin's principle of natural selection. Darwin says that he did not at first realize the overwhelming influence of the mass in its swamping effects on the individual variant. He made a very important concession to this view in the later editions of the "Origin of Species," and thought it necessary to assume that for a new form to arise it must first appear in a large number of individuals.

But to-day the situation has changed and new facts have come to light—facts that remove the enormous difficulty that Darwin met by what may seem now to have been an unnecessary concession.

An imaginary case will illustrate what I wish to say. Suppose that a species consisted in each generation of a million individuals and let us imagine that a new character—a definite variation—appears in an individual. The individual that bears it will pair with another ordinary individual and transmit its new character to all of its offspring. In order to simplify our case let us imagine that from each pair of individuals four reach maturity. The million of individuals has increased to two millions, but accidents and competition may kill off one million of these, so that the race is again reduced to its standard of one million. If, then, we suppose that two of the new kinds of individuals survive on the average, and pair at random, there will be eight in the next generation (in reality only six of the eight will show this character). If these survive they will transmit their character to twelve of their offspring. Gradually, however, step by step, the new character will be added to the whole race. Thus any new, definite character will gradually appear in all the individuals whether it is useful or not. If it is useful it may sooner implant itself on the race than if it is indifferent; for more individuals may survive that possess it, than of those without it. It will spread faster, but in any case it will come in the long run. Thus we see that it spreads, not because it is advantageous, but because it is a definite variation. Injurious characters will have greater difficulties in inflicting themselves on the race, and if distinctly injurious may never succeed.

While one character is spreading, other definite variations may also be adding themselves to the race. Those individuals that combine the greatest number of useful additions will have the best chance of survival. Slowly the race advances in the direction of the sum of its advantages and adaptation; success, not in one but in several characters, is the true criterion of survival.

To fix our attention on each single advantage and to ascribe to it alone the palm of victory gives an incomplete idea of the progress of evolution, for evolution follows the line of the greatest number of adaptations. Success in every generation cannot be traced to one variation, but to the sum of all mingled advantages.

This interpretation broadens, I think, our general conception of natural selection. We see that it is erroneous to suppose that all the individuals that bear a particular, useful trait owe this trait to their descent from one kind of individual, in the sense that this individual is the sole ancestor of all the later survivors. The first individual is not alone the ancestor of all the individuals that later bear its mark, it is only one of 999,999 ancestors that have contributed to the perpetuation of the race.

In order to simplify the case we have imagined that the new variation has appeared in a single individual. Should it appear in more than one, or arise again and again, its implantation would be thereby hastened, but the principle remains the same.

My contention may be summed up in a sentence. Survival-value is not the only test for the perpetuation of any one useful character; it is the sum total of useful variations that determines progress. The species moves as a group always. Evolution is not a simple but a complex problem. This is the general opinion held by most modern zoologists.

To-day there are three great rival claims that attempt to explain how evolution takes place: (1) that which adopts the theory of natural selection in one or another of its aspects; (2) that which maintains that acquired characters are inherited; (3) that which, trying to penetrate deeper into the mystery of life, ascribes to living matter a purposefulness—an almost conscious response to "the course of nature."

In a few concluding words I shall try to point out the standing of these rival claims.

Darwin himself adopted both the first and the second of these veiws. His whole philosophy stands opposed in principle to the third view. He did not hesitate at times to adopt the theory of the inheritance of acquired characters, whenever the facts seemed more in accordance with that interpretation than with that of natural selection. He strenuously objected that he had never intended to refer the entire process of evolution to natural selection, and later in life affirmed that he had perhaps laid too little stress on the influence of the environment. To-day the doctrine of inherited effects is in disgrace, largely owing to the brilliant attack of the philosopher of Freiburg. Nevertheless it has warm adherents; and not a few of the most cautious zoologists now living have expressed themselves in its favor. It has not lacked able advocates, but it has sadly lacked direct evidence to support it. I can show you an example of how it fails when put to the test. I have here a waltzing mouse that turns round in circles instead of moving forwards. This is a domesticated variety and breeds true, *i. e.*, all of its offspring are waltzers. I next show you a pair of mice that were injected with acetyl-atoxyl to cure them of sleeping sickness. They have artificially acquired the same habit as a result of the injection, and

have waltzed for nearly a year. Here are their offspring that show not a trace of the trick.

Cases like these, and I could cite not a few, show how cautiously we must view the theory that such acquired characters are inherited. The experiments do not disprove the possibility, but until direct evidence is forthcoming, judgment must remain suspended.

It has seemed, therefore, to many modern zoologists that we must face the two alternatives, either natural selection or purposeful response. Natural selection has been likened in recent years to a sieve that lets the non-adapted pass through and conserves the adapted. On the sieve metaphor natural selection produces nothing—it is described as a process of destruction of the unfit. How then can natural selection the destroyer become a factor in a creative process?

I have already tried to indicate how natural selection may assume such a rôle. If definite variations appear, however small or large, that are of some benefit, they may engraft themselves in time on to the species; if other useful definite variations are also adding themselves, if their presence insures some further definite variations in the same directions, advance is certain. In other words the elimination of the unfit has not produced the fit, but it has left the conditions more favorable for further progress in the direction of fitness. This is the interpretation of Darwinism that attracts at present the serious attention of the most thoughtful and advanced students of evolution.

I hesitate to bring before you in a closing sentence or two the alternative doctrine of purposefulness—a doctrine so fraught with human and superhuman import, for of all theories of creation it undoubtedly makes the strongest emotional appeal to mankind.

We are so conversant with the fact in human affairs that whenever purpose is involved there is an intelligent agent—a mind that designs, a mind that foresees—that our thinking has become tinctured with the idea that *wherever* there is purpose there is something like mind that has anticipated it. Organic nature is full to the brim of what seems purposeful adaptation—means to ends. Two modern zoologists and a noted philosopher have nailed this banner to their mast-head.

There is one consideration above all others that warns the zoologist against speaking dogmatically about purposefulness, or its absence, in the response of living matter to its environment—his ignorance of the causes of variation. If I have implied that *all* variation is purely "accidental"; if I have led you to infer that it is entirely fortuitous, I have gone beyond the facts. We must be careful to distinguish between the individual differences that we can safely ascribe to chance, and the small definite variations that arise in the germ. The latter appear to be limited, to be in part determined by the internal nature of the parts affected, and to be constant when they have once appeared, but more than this we dare not affirm. We may believe if we like that the evidence

indicates that they are not purposeful, but we can not prove this. If *they* are not purposeful then the purposefulness of the living world has no *direct* relation to the origin of useful variations. The origin of an adaptive structure and the purpose it comes to fulfill are only chance combinations. Purposefulness is a very human conception for usefulness. It is usefulness looked at backwards. Hard as it is to imagine, inconceivably hard it may appear to many, that there is no direct relation between the origin of useful variations and the ends they come to serve, yet the modern zoologist takes his stand as a man of science on this ground. He may admit in secret to his father confessor, the metaphysician, that his poor intellect staggers under such a supposition, but he bravely carries forward his work of investigation along the only lines that he has found fruitful.

In the last analysis it is a matter of expediency; or if the word jars, a matter of instinct. Why forsake the gold mine at our feet, because the transmutation of metals is a philosophic possibility?

Whether definite variations are by chance useful, or whether they are purposeful are the contrasting views of modern speculation. The philosophic zoologist of to-day has made his choice. He has chosen *undirected* variations as furnishing the materials for natural selection. It gives him a working hypothesis that calls in no unknown agencies; it accords with what he observes in nature; it promises the largest rewards. He does not deny, if he is cautious, the possibility that there may be a purposefulness in the sense that organisms may respond adaptively at times to external conditions; for the very basis of his theory rests on the assumption that such variations do occur. But he is inclined to question the assumption that adaptive variations *arise because* of their adaptiveness. In his experience he finds little evidence for this belief, and he finds much that is opposed to it. He can foresee that to admit it for that all important group of facts, where adjustments arise through the adaptation of individuals to each other—of host to parasite, of hunter to hunted—will land him in a mire of unverifiable speculation. He *fears* to enter thereby on a field of exploitation of nature that has proved itself so sterile in the past.

We have reached the end of our theme. If I have led you too far into some of the remote corners of zoological thought, I must plead that such thoughts are the legitimate outgrowth of Darwinism.

I have tried to show you the modern zoologist at work on the great theory of evolution. We stand to-day on the foundations laid fifty years ago. Darwin's method is our method, the way he pointed out we follow, not as the advocates of a dogma, not as the disciples of any particular creed, but the avowed adherents of a method of investigation whose inauguration we owe chiefly to Charles Darwin. For it is this spirit of Darwinism, not its formulæ, that we proclaim as our best heritage.

PREDARWINIAN AND POSTDARWINIAN BIOLOGY[1]

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CHARLES DARWIN undoubtedly exerted a profound and threefold influence on botany, zoology and all the kindred sciences; first, by his rehabilitation of Lamarck's theory of transformism, or evolution, as it is more generally but less aptly called; secondly, by his wonderful studies on variation; and thirdly, by the announcement of his brilliant theory of natural selection through the survival of the fittest. There is much difference of opinion as to which of these constitutes Darwin's most glorious achievement. Neodarwinists regard the promulgation of the theory of natural selection as his greatest work; experimental zoologists and botanists attribute to his studies on variation a deeper and more salutary influence on present and future investigation; while Neolamarckians insist that his labors in the cause of evolution in general, quite irrespective of whether it be conceived to result from natural selection or from other factors, is his most important contribution, not only to biological science, but to the whole body of modern thought. With this last estimate I believe that most conservative men of science will agree. Just how Darwin's work has compelled us to change our attitude so radically towards the world about us can be made clear if you will permit me very briefly to contrast the tendencies of ancient and modern science.

The unceasing flux of phenomena which is all that science can deal with has been envisaged very differently by ancient and modern observers. The Greek scientist fixed his attention on particular moments or aspects of phenomena, so that science became to him a static edifice of concepts or ideas, a hierarchy of genera and species. The scientist of to-day does not thus concentrate his attention on single moments to the exclusion or neglect of all other aspects of a phenomenon, but seeks to obtain a complete knowledge of the uniformities and constants in its occurrence and recurrence. For this reason modern science is dynamic and lays stress on laws and not on the definition and classification of concepts and ideas. These important differences between ancient and modern science have been clearly pointed out by the eminent French philosopher, Henri Bergson, in the following words:

> Ancient science believed that she understood her object when she had noted its privileged moments, whereas modern science considers it at any

[1] Read before the Boston Society of Natural History, February 12, 1909.

moment. The forms or ideas of a Plato or an Aristotle correspond to privileged or salient moments in the history of things—the very same moments, generally speaking, that have been fixed by language. They are supposed, like the infancy and old age of a living being, to characterize and express the quintessence of a period, all the remainder of which is filled with the transition from one state to another, and is, therefore, devoid of interest in itself. Consider, for example, the falling of a body. It was thought to be a sufficient account of the fact when it had been characterized summarily as a movement *downward*, a tendency towards a *center*, the *natural* movement of a body, which, after being separated from the earth to which it belongs, returns again to its original position. Therefore, the final or culminating point (Τέλος, ἀκμή) of a process is singled out and is erected into an essential moment, and science is satisfied with this moment, which language has seized upon for the purpose of expressing the *ensemble* of the fact. In the physics of Aristotle, the movement of a body hurled through space, or freely falling, is defined by concepts of above and below, of spontaneous and enforced displacement, of proper and improper position. But Gallilei believed that there was no essential moment, no privileged instant; in his opinion one should be able to give an account of a falling body at any moment in its course, for that is the true science of gravitation which determines the position of a body in space at any instant of time. For this purpose we, of course, need more precise symbols than those of language.[2]

To Aristotle we may also turn for a biological illustration of the differences between ancient and modern scientific observation. According to his conception, the type or privileged moment of humanity is represented by the adult male individual, with reference to whom youth and age are merely incipient and declining stages respectively, and woman is merely an abortive attempt on the part of nature to produce a man. Contrast with this our present biological conception of the sexes and the ontogeny of the human species!

It must be admitted that the tendency of modern science is in the direction of much greater refinement on the ancient method, a tendency to scrutinize more humbly and more closely, and hence, to multiply indefinitely the observed moments and aspects. I, therefore, do not use the term "ancient" in the sense of "no longer existing," since the tendency thus designated is still constantly manifested in all our ordinary thinking. To observe and retain only the privileged moments and aspects of things is for very many purposes eminently practical, but it has its disadvantages, for the more such moments of an object are accentuated or exalted, the more insignificant or debased become its other aspects. Such emphasis may be highly artistic, but it is contrary to the spirit of modern science. Indeed, much of the lack of sympathy that exists between men of extremely artistic and extremely scientific temperament is due to this difference of instinctive attitude towards the world of phenomena.

It is well known that in their development the biological have

[2] "L'Evolution Créatrice," 4th edition, 1908, pp. 357, 358.

always lagged behind the physical sciences. This is attributable in large measure, of course, to the greater complexity of organic phenomena, but I suspect that the fact that animals and plants admit of an arrangement in generic and specific categories, which seem at first sight to be in singular harmony with the spirit of ancient science and philosophy, may be to a considerable extent responsible for the stolid conservatism of systematic biology. At a time when the physical sciences, through the labors of Kepler, Gallilei and Newton, had already become modern sciences in the true sense of the word, biology was still practically in the Greek stage. This is certainly true of zoology and botany proper up to the middle of the last century, although zoology had through medicine contracted some of the modern spirit, since by that time anatomy and physiology had definitively abandoned Greek and scholastic methods.

At this juncture appeared Darwin's "Origin of Species." The effect of this work was in the first instance destructive, for it tended to dissolve and mobilize the rigid conceptual schematism that dominated, not only the zoology and botany, but the whole cosmology of the time. The conception of an evolution which melted all living beings, man included, into a single vital stream, surging on into the future as it has surged through the æons of the past, continually creating new and destroying old forms, could not fail to clash with the conception of a world created once for all and since engaged very largely in marking time. According to the old view, living objects are more or less vitiated Platonic ideas or Aristotelian forms, according to the new they are eddies or whirlpools in a living current that modify and regulate their movements according to the obstacles, *i. e.*, the "environment" which they encounter. No wonder men like Cuvier declined to accept the doctrine of evolution when it was first promulgated by Lamarck, and that von Baer and Louis Agassiz regarded its rehabilitation by Darwin as a heresy. All of these men believed in the existence of permanent types of organic structure, which, after all, were merely Platonic ideas parading under assumptions more or less theological, privileged moments or aspects of animal and plant morphology interpreted as thoughts of the Deity. It is quite unnecessary to mention the innumerable scholastic and theological opponents of evolution. Their animosity certainly had and still has other motives than a predilection for the Mosaic account of creation.

It is far pleasanter to contemplate the constructive aspects of Darwin's work. Since evolution, as conceived by him, admitted of a mechanical explanation — for survival through natural selection is mechanical and not teleological like survival through psychical effort as postulated by Lamarck—it breathed the spirit of the physical sciences and therefore allied itself with these rather than with psychology and

philosophy. When presented with Darwin's conception of evolution, the botanist and zoologist could no longer remain satisfied with mere contemplation of privileged moments. It became necessary to attend to every aspect of the organism. Every phase of its development from the egg to its dissolution, and every particle of its structure had to be submitted to the closest examination, for no character—so ran the theory—was too insignificant to decide whether a species could survive in the struggle for existence. Indeed, even vestigial and rudimental characters began to assume an astonishing importance as witnessing to the past and prefiguring the future history of the species. Such close scrutiny of the entire life-cycle and structure of organisms was also necessitated by Darwin's assumption that the evolution of organic forms is a very gradual process, requiring enormous periods of time. Hence the incentive to record the minutest variations and adaptations and to search for their causes. From the same source sprang the inspiration to study the lower animals and plants with the utmost care and in all their aspects, for these forms—according to the theory—had departed least from the first, simple beginnings of life on our planet, and might, therefore, be expected to throw light on the initial movements of organic evolution. But the animals at the other end of the organic scale were not to be neglected, for the theory which made man a blood relation of the higher mammals could not fail to arouse universal interest in these and all the other vertebrates. And not only did it become necessary to investigate the plants and animals *now* living on the earth, but the strata of the planet had to be ransacked for evidences of past evolutionary history. Paleontology was born anew, and the distribution of life in the present and past became a subject of absorbing and ardent study. Even the most conservative branch of biology, the classification of animals and plants, was shaken to its foundations by the theory of evolution, for under its solvent action the old conceptions of the genus and species, and all the other taxonomic categories, lost their rigid outlines and became fluid and dynamic. In proof of all these statements concerning the immediate effects of the promulgation of the theory of evolution, we have only to glance at the marvelous development during the past fifty years of anatomy, embryology, histology, cytology and physiology, both human and comparative, and of paleontology, chorology, ethology and taxonomy, both botanical and zoological.

The constantly increasing tendency during the past half century to substitute a careful genetic study, that is, a study of all the stages of the life-processes, with a view to establishing the laws or constants of their occurrence, for the ancient cut and dried methods of defining and classifying concepts obtained from the contemplation of privileged moments in the vital flux, has spread far beyond the confines of biology properly so-called. Psychology, which is the most closely related of all

the mental sciences to biology, has been revolutionized. Its students have abandoned the old facultative and associationist schematism and turn with renewed interest to the psychology of emotion, volition and instinct, to animal and child psychology and the normal and pathological psychology of the various human races. Mind is no longer looked upon as a thing, but as a living process, the study of which must be undertaken with far subtler methods than were ever dreamed of by the ancient and mediæval psychologists. Philosophy, ethics and religion, which are all so intimately bound up with psychology, are also at last breaking away from conceptualism and absolutism. This is clearly seen in the works of the pragmatists and humanists, and among theological writings in what has been called modernism. These tendencies of the mental sciences have also reached out into sociology, anthropology, archeology, philology, economics and education. Even the fine arts, though still necessarily addicted to the glorification of certain privileged or dramatic moments, have been seized with the modern scientific craving to multiply these moments indefinitely and thus to increase our delight and interest in the full efflorescence of life and its cosmic setting.

Some may doubt whether these marvelous changes in all modern intellectual endeavor have been brought about by the doctrine of evolution. Of course, even if Darwin had never lived and if the doctrine of evolution had never been revived, it is certain that the biological sciences would have developed considerably during the past fifty years merely by following in the footsteps and by adopting the methods of physics and chemistry, but that Darwin's thought quickened, exaggerated and dominated this development cannot be doubted. And even if we go so far as to say that natural selection may eventually prove to be an unimportant factor in evolution, to be consigned to the limbo of defunct hypotheses, together with Darwin's views on pangenesis, sexual selection and the origin of species from fluctuating variations, we must, I believe, still admit that the great English naturalist opened up before us a vast new world of thought and endeavor. But for the doctrine of evolution we should still be contemplating living organisms from afar and in a more or less scholastic and theologizing spirit, like the biologists of the first half of the nineteenth century, and not as now, at close range and with a deeper and freer insight into the significance of the minutest details of development, structure and function.

THE HALO OF A HUNDRED YEARS[1] (FEBRUARY, 1809, TO FEBRUARY, 1909)

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IN ordinary circumstances, a humble representative of Wissenschaft der Philosophie, like myself—a pursuer rather than a possessor of knowledge, would deem any poor words of his superfluous on such an occasion, and in an assembly composed chiefly of those who have consecrated their lives to the natural sciences. But, to-night, I am so bold as to proffer claim to a little niche, because we are to make a pregnant pause, and enjoy an interchange of ideas, in commemoration of the illustrious name, services and discoveries of Charles Robert Darwin, who first saw the light at Shrewsbury, on February 12, 1809, that memorable year of memorable infants.

Place aux dames, as if Darwin were not enough, 1809 gave us Elizabeth Barrett Browning, Mary Cowden Clarke, the Shakespeare scholar, and Fanny Kemble, the great actress. In science, it produced Grassmann and Liouville, the eminent mathematicians; the botanists K. H. E. Koch and George Engelmann; the geologist J. D. Forbes; Jakob Henle, the anatomist; Fitch, the economic entomologist; Stöckhardt, the founder of agricultural experiment stations; and Griscom, the physician. Its children made literature immensely their debtor, for, among them were Tennyson, Edgar Allan Poe, Charles Lever, Monckton Milnes (Lord Houghton), Oliver Wendell Holmes, Mark Lemon (the humorist), Edward Fitzgerald, who rendered Omar Khayyam an English classic; Paludan-Müller, an ornament of Scandanavian letters; Giusti, the Tuscan poet, whom his countrymen delight to call the Béranger of Italy; and Nikolaus Becker, author of that famous song, "Der deutsche Rhein." In music we owe it Chopin and Mendelssohn; in art, Diaz de la Peña, the French landscape painter; in history, Hefele, John Hill Burton, Kinglake, Skene, Cronholm, Bruno Bauer, and Michael Horvath, greatest of Hungarian historians; in scholarship, Theodor Benfey and John Stuart Blackie; in theology, Isaac Dorner; and, in practical religion, Selwyn, the influential missionary-bishop of New Zealand. The educationist, Barnard; the jurist, Phillimore; the publicist, William Rathbone Greg; the philanthropist, Miall, and Baron Hausmann, who found Paris brick and left it

[1] Address of the president of the Research Club of the University of Michigan, on the occasion of the Darwin commemoration.

marble, were born in 1809, like the philosophers Vacherot and Franck, in France; Tari, in Italy; Nielsen, in Denmark; and Bledsoe, in this country. In the arts of war it bore at least four leaders of distinction—Canrobert, marshal of France; Manteuffel, first governor of the *Reichsland* after the fall of Napoleon III.; Dahlgren, the American admiral, an authority on ordnance; and Menabrea, the Italian engineer, an eminent name in the science of fortification. Its most noted diplomatist was Rutherford Alcock, who saw some of the stress that accompanied the introduction of occidental civilization into Japan, and whose bread, cast upon the waters long ago, has returned to such consequence after many days. Finally, as if to round out the universe of human activity, 1809 brought to birth two immortal statesmen—Lincoln, who was born on the same day as Darwin, and Gladstone.

Now notwithstanding the multifarious activities, incalculable influence, and momentous events, connected with these fifty-four names—an extraordinary galaxy—there can be little doubt that, setting aside place and, in particular, nationality, Darwin has laid profoundest hold upon the universal imagination of mankind. And the obvious question arises, why? Let us look at this for a little; it is much easier to ask than to answer.

In this presence, it would be an impertinence on my part were I to wander into the problem of evolution as understood by students of natural science. But, possibly, I may be able to contribute my tiny mite from another standpoint.

We may take it as axiomatic that genius achieves supremacy very rarely against, or without, the cooperant "social mind," and that it pays the price for lone attainment by missing highest rank. To adopt Matthew Arnold's phrase, the man and the moment must agree; or, as Goethe said, only he who unites with the many at the right moment ever becomes great. If I be not far wide of the mark, Darwin enjoyed peculiar fortune in this respect and, thanks to his extraordinary patience, backed by unusual perseverance and devotion, came to enthrone himself amid the master intellects typical of the nineteenth century.

To begin with, then, we must bear in mind that centuries are arbitrary divisions, that no break assails the onward movement of thought, and that every age serves itself upon its successor. The immense displacements, due to the Renascence in the fifteenth century, and to the Reformation in the sixteenth, carried over into the seventeenth; while the seventeenth lived on in the eighteenth, just as the eighteenth, thanks probably to political and social conditions, continued to rule the nineteenth to 1873 (death of John Stuart Mill), say, especially in the English-speaking countries. Indeed, much of the opposition encountered by evolution from the man in the street, and from pseudo-thinkers, may be traced to this simple fact. Nay, we can trace its potent influ-

ence in Darwin himself. The main limitation of his theory results from its bondage to the idea of utility—a heritage from the eighteenth century. In illustration of these cross-currents, still inexplicable, recall that Monge, the mathematician, though born in 1746, was essentially a nineteenth century man; so was Lamarck, born two years earlier; so was Erasmus Darwin, even if sixty-nine of his seventy-one years belonged to the heyday of Pope, Johnson and Paley. Similarly, when we face towards the future rather than the past, we find the seminal ideas of the nineteenth century already astir soon after the middle of the eighteenth. Winckelmann, in 1758; Lessing, in 1766; and, more plainly, Herder, in 1786, are apostles of synthetic as opposed to analytic methods, of "life-history" as against mere taxonomy. Listen to Herder, and note how he prophesies the genetic era:

> Among millions of creatures whatever could preserve itself abides, and still after the lapse of thousands of years remains in the great harmonious order. Wild animals and tame, carnivorous and graminivorous, insects, birds, fishes and man are adapted to each other.

And again, on the side now of the human sciences:

> All the songs of primitive peoples turn on actual things, doings, events, circumstances, incidents, on a living, manifold world. All this the eye has seen, and since the imagination reproduces it as it has been seen, it must needs be reproduced in an abrupt fragmentary manner. There is no other connection between the different parts of these songs than there is between the trees and bushes of the forest, the rocks and caverns of the desert, and between the different scenes of the events themselves.

You see the same thing in Goethe's "Iphigenie" (1787), in his "Versuch die Metamorphose der Pflanzen zu erklären" (1790), and his "Zur Morphologie" (1795–1807), above all, in "Faust," erster Theil (1808). Small wonder, then, that the systematic thinkers bred in the same movement, Kant aside, should be dominated by the genetic idea of development; and even Kant, especially in his "Kritik der Urtheilskraft" (1790), to say nothing of the extraordinary prevision of his "Allgemeine Naturgeschichte und Theorie des Himmels" (1755), is not without latent suspicions concerning the direction to be taken by the new tide. To mention none of his other manifold services —of which, in a company of investigators, the part he played at the foundation of the University of Berlin should merit particular remembrance—Fichte's "Der geschlossene Handelsstaat" (1800), originates a line of socio-economic thought thoroughly characteristic of Darwin's epoch, and affiliated sometimes with biology. Schelling's "Einleitung zum Entwurf eines Systems der Naturphilosophie" (1799), as I have tried to show in another place,[2] exercised no little formative power over a group of his countrymen who made important contributions to the early modern phases of physiology, chemistry, botany,

[2] "The Movement Towards 'Physiological' Psychology," pp. 75 f.

anatomy and medicine. Still, when all is said and done, Hegel shone the bright particular star of the constellation. Indeed, so far as our perplexing proximity permits fair judgment, we must rank him foremost among the systematic thinkers of the nineteenth century. The ceaseless praises and recriminations that have encompassed his memory ever since his death, in 1831, prove no less. Present signs of his returning influence among the Teutonic peoples indicate much the same thing.

But, some one will inquire, what has all this to do with Darwin's hold upon the general imagination? I answer, everything! For while, schooled by long neglect, even contumely, we philosophers have learned to consume our own smoke in comparative silence, you, my scientific colleagues, may be prepared to take the word of one who, perhaps more than any of your coadjutors, possesses the right to speak with authority on the occasion of the Darwin Centennial. Professor H. F. Osborn writes:

> It is a very striking fact that the basis of our modern methods of studying the evolution problem was established not by the early naturalists nor by the speculative writers, but by the philosophers. They alone were upon the main track of modern thought.[3]

Many proofs might be adduced readily. Two mere indications must suffice here. Hegel, for instance, insists, and rightly, that the botanists of his day, obsessed by classification, did not realize the force of Goethe's position, "eben weil ein Ganzes darin dargestellt wurde."[4] Again, Goethe himself formulated Spencer's famous principle about the passage from indefinite, incoherent homogeneity to definite, coherent heterogeneity. Goethe points out:

> The more imperfect a being is the more do its individual parts resemble each other, and the more do these parts resemble the whole. The more perfect the being is, the more dissimilar are its parts. In the former case the parts are more or less a repetition of the whole; in the latter case they are totally unlike the whole. The more the parts resemble each other, the less subordination is there of one to the other. Subordination of parts indicates high grade of organization.[5]

But, like other incalculable human forces, the idealists bore their manifest limitations. And Hegel may be taken as their consecrated representative. Perhaps we may understand this matter best by saying that, after a fashion, he came too soon. His central thesis embodied a theory of universal development, a theory that has had no parallel for boldness and penetration since Plato and his unique pupil, Aristotle. Now, a huge framework of this sort needs multifarious filling in. And one may well admire the temerity of the philosopher when he recalls the condition of knowledge between 1812 and 1816, the years that wit-

[3] "From the Greeks to Darwin," p. 87.
[4] "Naturphil.," p. 489.
[5] "Life of Goethe," G. H. Lewes, p. 358.

nessed the successive volumes of Hegel's masterpiece. All things considered, the physical sciences as we know them now—astronomy, geology, physics and chemistry, as well as mathematics in large part—had hardly begun their latest growth; the biological sciences, in their splendid structure of to-day, were still ahead; while the entire group of human sciences, created mainly by the impetus lent by Hegel himself, in the nature of the case, had not entered upon significant formulation. In a word, the idea of development saturated the intellectual atmosphere; nevertheless, the elaborate and toilsome labor of thinking it through piecemeal for the endless realms of nature, and for the subtlest manifestations of consciousness, lay in the future. Here Darwin, like many another, found his opportunity.

In the second place, he was favored by the situation dominant in the field of science as a whole, no less than by his own preeminently cautious and "concrete" mind. With regard to the latter, we have a characteristic statement from his pen, in the form of a letter to Herbert Spencer, acknowledging a copy of the "Essays." Recall that, not long before, Spencer had been writing to Huxley on the subject of Owen, who was to damn Darwin with faint praise eighteen months after,[6] and had expressed himself as follows:

> I am busy with the onslaught on Owen. I find on reading, the "Archetype and Homologies" is terrible bosh—far worse than I had thought. I shall make a tremendous smash of it, and lay the foundations of a true theory on its ruins.[7]

From one point of view, this is still the nineteenth century against the eighteenth. Darwin's letter, dated 25th November, 1858—one year precisely before the "Origin of Species"—runs thus:

> Your remarks on the general argument of the so-called Development Theory seem to me admirable. I am at present preparing an abstract of a larger work on the changes of species; but I treat the subject simply as a naturalist, and not from a general point of view; otherwise, in my opinion, your argument could not have been improved on, and might have been quoted by me with great advantage.[8]

If Hegel evinced intuitive grasp upon the general framework of development, Darwin's cautious genius led him to exercise superlative perseverance in conquering difficult provinces of the detailed phenomena incidental to evolution.

At the same time, Darwin valued the aid of generalization and

[6] It is generally understood now that the review of the "Origin of Species" published in the *Edinburgh Review* for April, 1860, was by Owen. At this time, all who have access to it should refresh their memories by reading it. The tone of Spencer's references explains not a little to be found in this critique, especially its concluding emphasis upon the superiority of Cuvier.

[7] "Life and Letters of Herbert Spencer," D. Duncan, Vol. I., p. 112,

[8] *Ibid.*, p. 113.

hypothesis, to which many naturalists, misled by Bacon's thoroughly unscientific temper, had been too averse: Accordingly, the trend of scientific method had become tainted, if not with disastrous consequences, at least with results inimical to progress, as we account means of progress now. This, the former of the two aspects mentioned above, has been delineated admirably by Romanes, from whom, I may say in passing, I derived the only knowledge of Darwin's personality, conveyed at first-hand by a mutual friend, that I possess.

He nowhere loses sight of the primary distinction between fact and theory; so that, thus far, he loyally follows the spirit of revolt against subjective methods. But, while always holding this distinction clearly in view, his idea of the scientific use of facts is plainly that of furnishing legitimate material for the construction of theories. Natural history is not to him an affair of the herbarium or the cabinet. The collectors and the species-framers are, as it were, his diggers of clay and makers of bricks; even the skilled observers and the trained experimentalists are his mechanics. Valuable as the work of all these men is in itself, its principal value, as he has finally demonstrated, is that which it acquires in rendering possible the work of the architect. Therefore, although he has toiled in all the trades with his own hands, and in each has accomplished some of the best work that has ever been done, the great difference between him and most of his predecessors consists in this—that while to them the discovery or accumulation of facts was an end, to him it is the means. In their eyes it was enough that the facts should be discovered and recorded. In his eyes the value of the facts is due to their power of guiding the mind to a further discovery of principles. And the extraordinary success which has attended his work in this respect of *generalization* immediately brought natural history into line with the other inductive sciences, behind which, in this most important of all respects, she has so seriously fallen. For it was the "Origin of Species" which first clearly revealed to naturalists as a class, that it was the duty of their science to take as its motto, what is really the motto of natural science in general,

Felix quit potuit rerum cognoscere causas.

Not facts, then, but causes or principles, are the ultimate objects of scientific quest. . . . The spirit of speculation is the same as the spirit of science, namely, as we have just seen, a desire to know the causes of things. . . . And to frame hypotheses is to speculate. . . . The difference between science and speculation is not a difference of spirit; nor, thus far, is it a difference of method. The only difference between them is in the subsequent process of verifying hypotheses. . . . The only danger of speculation consists in its momentum being apt to carry away the mind from the more laborious work of adequate verification; and therefore a true scientific judgment consists in giving a free rein to speculation on the one hand, while holding ready the break of verification with the other. Now, it is just because Darwin did both these things with so admirable a judgment, that he gave the world of natural history so good a lesson as to the most effectual way of driving the chariot of science.[1]

While it may well be impossible to assail Romanes's panegyric, and while it is eminently fitting that we should throb to its mood at this time, Darwin would have been the last man to magnify his own office,

[1] "Darwin and After Darwin," Vol. I., pp. 4–7 (London, 1892).

or to deny his heritage from predecessors. Just as the Neapolitan philosopher-jurist, Vico (1668–1744), foresaw some of the transitive ideas that thinkers from Herder to Hegel, and philologists from F. A. Wolf and Niebuhr, were to clarify, so, too, Goethe and Erasmus Darwin, Lamarck and Chambers, had substituted evolution for spontaneous generation and special creation ere Darwin's day. But two tasks remained, for whose accomplishment Darwin's endowments of mind and character were to the manner born. First, an enormous accumulation of evidence stood in need. This Darwin furnished on a scale still unparalleled by any single investigator. Second, it was necessary to experiment with tentative and candid applications of the evolution hypothesis, apart altogether from flamboyant allegations that the key to every mystery had been grasped at length. Darwin's scientific conscience, and his eminently sane, self-effacing character, equipped him rarely for these essential services. And, with him, evolution may be said to have attained a poise lost somewhat since, I fear, amid the clash of new theories and rival schools, even nations. After long years devoted to excursions in many fields of intellectual activity, I, at least, have met no one who, with such a heady prospect in plain sight, knew how to hold the balance so true as the author of the "Origin of Species." One might almost go so far as to call him *the* proof, *in propria persona*, of Hegel's profound deliverance: "Not only must philosophy be in harmony with experience, but empirical natural science is the presupposition and condition of the rise and formation of the philosophical science of nature."[10]

And this leads, naturally, to a few words concerning Darwin's circumstances, and his character as a man.

Taken on the whole, his achievement happens to be thoroughly typical of English science, in contrast with German, French, or even Scottish, not to say American, methods. He wrought in an independence of others that amounted almost to loneliness. He seems to have gained no inspiration from his teachers at Edinburgh and at Cambridge from none except Henslow, through whose instrumentality he undertook the famous voyage on the *Beagle*. In 1842, while yet a young man, he retired to Down, in Kent, there to mature his epoch-making investigations "far from the madding crowd," but, nevertheless, to show his age its own express image.

As with so many Englishmen of foremost rank in science, he stood apart from that organization of *Wissenschaft* provided by the institute and academies of France, by the university system in Germany and Scotland. We must think of him, in the main, as we think of Young, who presented his fundamental discoveries on the undulatory theory of light in such obscure ways and channels that they never received due

[10] "Naturphil.," p. 11.

contemporary recognition; of Dalton, who, working as a private teacher at Manchester, was first appreciated in the University of Glasgow; of George Green, the self-taught Nottingham genius, who anticipated Gauss in elaborating the general mathematical theory of potential function, and who was also made known to European science by my *alma mater;* of Boole, who, though the founder of the science of invariants, taught in "venture" schools at Doncaster and Lincoln, and never climbed higher than the professorship of mathematics at an inconspicuous Irish college;[11] of Faraday and Joule, whose pertinacious, unaided labors were also rated first at their real worth in the University of Glasgow; of the Yorkshire shepherd, Dawson, who made Senior Wranglers at Sedbergh in the last years of the eighteenth century. All these men—and I might name others, like the classical succession of English philosophers—were personalities, not ranking officers in a national syndicate of scientific feudalism. Darwin stood latest in their wonderful, and characteristically English, line. The Englishman's passion for independence, his desire for the free play of idiosyncrasy, may account for this. More powerful, in my judgment, is the fact that the pursuit of science had not become a profession, and with the astonishing consequences noted so caustically by Brewster, in 1830.

> The great inventions and discoveries which have been made in England during the last century have been made without the precincts of our universities. In proof of this we have only to recall the labours of Bradley, Dollond, Priestley, Cavendish, Maskelyne, Rumford, Watt, Wollaston, Young, Davy and Chenevix; and among the living to mention the names of Dalton, Ivory, Brown, Hatchett, Pond, Herschel, Babbage, Henry, Barlow, South, Faraday, Murdoch and Christie; nor need we have any hesitation in adding that within the last fifteen years not a single discovery or invention of prominent interest has been made in our colleges, and that there is not one man in all the eight universities of Great Britain who is at present known to be engaged in any train of original research.[12]

(A *research* club takes due note, I hope!) Science lay in far deeper debt to the unusual endowment of individuals than to the patronage of academies, or the fostering stimulus of universities, true to the highest trust of education. In this connection, then, note finally that Darwin's character furnished an ideal instrument for the continuation of this process, *more Anglicano.*

On the intellectual side, Darwin's character presented a combination, unique in modern times at least, of extensive knowledge, profound sagacity and deliberative caution. His mastery over detail simply overwhelms one. His sense for relationship and consequent power to detect a single principle, no matter how confusing the multiplied phenomena

[11] Queen's College, Cork.

[12] *Quarterly Review,* Vol. XLIII., p. 327. This article led to the foundation of the British Association. Cf. "The English Utilitarians," Leslie Stephen, Vol. I., pp. 47 f., 112.

might be, lent him the ability that was to restore synthesis to its lost place in scientific method. Still, fertile though he proved along theoretical lines, his caution prevented him from riding off, heedless, upon preconceived notions. In this connection, it is a fact worthy of constant note that he refused to discuss questions about the origin of life, and the genesis of the earliest living organisms—subjects fraught with wandering lights. My own ignorance of the field wherein he labored may lead me into error, but, nevertheless, I do not think I am far wrong when I affirm that the adjuncts of his systematization which have least stood the test of time, thanks to manifold discoveries, his fruitage, were precisely those framed as concessions to the opinions of others. His very inability to dogmatize, and his readiness to enter into the standpoint of colleagues, illustrated his mighty virtue of second thought, nigh in the act of overreaching itself. Accordingly, it makes small difference to what extent further investigation may have complicated the problem of the *means* of evolution; his illuminating and thorough presentation of the *fact* stands untouched. The dilemma becomes plainer every day—either evolution, or irrational chaos.

On what may be called the ethical side, his personality exercised immense influence over his intimates and won upon them deeply. A brilliant and witty conversationalist, his refinement and sensitiveness placed even the youngest at ease, while his benevolent wisdom tied men to him by bands stronger than steel. Like all real masters of those who know, he was charmingly unconscious of his eminent genius, and his unaffected modesty led him to see achievements surpassing his own in many a one. What he wrote of Henslow offers a most apposite commentary upon himself.

> **Reflecting over his character with gratitude and reverence, his moral attributes rise, as they should do in the highest characters, in preeminence over his intellect.**

But, to my mind, the most impressive testimony to Darwin's personal nobility comes, not from any of his devoted friends, but from Leslie Stephen, a critic averse constitutionally from ecstatic praise of any one. He even says: "I should like to succeed in praising somebody some day."[13] Remember, too, that Stephen was on terms of familiarity with the chief figures of the Victorian era, that his own family had produced men of high distinction, and that he married a daughter of Thackeray. Yet, temperament and opportunity notwithstanding, Darwin overtopped all others with him. The venerable naturalist had been to see him in London, and Stephen writes to Charles Eliot Norton, in 1877:

> **You may believe that I was proud to welcome him, for of all eminent men that I have ever seen he is beyond comparison the most attractive to me. There is something almost pathetic in his simplicity and friendliness.**

[13] "The Life and Letters of Leslie Stephen," p. 307.

I heard a story the other day about a young German admirer, whom Lubbock took to see him. He could not summon up courage to speak to the great man; but, when they came away, burst into tears. That is not my way; but I can sympathize to some extent with the enthusiastic Dutchman.[14]

Although Darwin must have been tried sorely by vulgar misrepresentation, partisan spite, ignorant invective and foul traduction, "he never took an ill-natured view of any one's character." His conduct midmost the cataract of abuse let loose upon the "Origin of Species" constitutes a glorious monument to his elevation of soul. His open simplicity earned the reverence no less than the affection of those who were privileged to know him. And, as we now place our bays upon his crowned memory, we may adopt the words of the Scottish poet, an acquaintance of my college days, whose sonnet voices the truth so finely:

Man's thought is like Antæus, and must be
Touched to the ground of Nature to regain
Fresh force, new impulse, else it would remain
Dead in the grip of strong Authority.
But, once thereon reset, 'tis like a tree,
Sap-swollen in spring-time: bonds may not restrain;
Nor weight repress; its rootlets rend in twain
Dead stones and walls and rocks resistlessly.

Thine then it was to touch dead thoughts to earth,
Till of old dreams sprang new philosophies,
From visions systems, and beneath thy spell
Swiftly uprose, like magic palaces,—
Thyself half-conscious only of thy worth—
Calm priest of a tremendous oracle!

[14] *Ibid.*, pp. 300, 301.

THE ORIGIN OF THE THEORY OF NATURAL SELECTION[1]

By Dr. A. R. WALLACE

I BEG to thank the council of the Linnean Society for the very great honor they have done me, in coupling my name with that of Charles Darwin on the celebration of this anniversary, and for the still greater and more exceptional honor, of perpetuating my features with those of my illustrious forerunner, upon the medal you have now awarded me.

With your permission I propose to make a few remarks both as to the actual relations between Darwin and myself prior to July, 1858, and also to some peculiarities of our respective life-histories which brought about those relations, and which will, I hope, be both novel and of some general interest.

Since the death of Darwin in 1882, I have found myself in the somewhat unusual position of receiving credit and praise from popular writers under a complete misapprehension of what my share in Darwin's work really amounted to. It has been stated (not unfrequently) in the daily and weekly press, that Darwin and myself discovered "natural selection" simultaneously, while a more daring few have declared that I was *the first* to discover it, and that I gave way to Darwin!

In order to avoid further errors of this kind (which this celebration may possibly encourage), I think it will be well to give the actual facts as simply and clearly as possible.

The *one fact* that connects me with Darwin, and which, I am happy to say, has never been doubted, is that the idea of what is now termed "natural selection" or "survival of the fittest," together with its far-reaching consequences, occurred to us *independently,* and was first jointly announced before this society fifty years ago.

But, what is often forgotten by the press and the public, is, that the idea occurred to Darwin in October, 1838, nearly twenty years earlier than to myself (in February, 1858); and that during the whole of that twenty years he had been laboriously collecting evidence from the vast mass of literature of biology, of horticulture and of agriculture: as well as himself carrying out ingenious experiments and original observations, the extent of which is indicated by the range of subjects discussed in his "Origin of Species," and especially in that wonderful store-house of knowledge—his "Animals and Plants under Domestica-

[1] Reply on receiving the Darwin-Wallace medal of the Linnean Society of London on July 1, 1908.

tion," almost the whole materials for which works had been collected, and to a large extent systematized, during that twenty years.

So far back as 1844, at a time when I had hardly thought of any serious study of nature, Darwin had written an outline of his views, which he communicated to his friends Sir Charles Lyell and Dr. (now Sir Joseph) Hooker. The former strongly urged him to publish an abstract of his theory as soon as possible, lest some other person might precede him—but he always refused till he had got together the whole of the materials for his intended great work. Then, at last, Lyell's prediction was fulfilled, and, without any apparent warning, my letter, with the enclosed essay, came upon him, like a thunderbolt from a cloudless sky! This forced him to what he considered a premature publicity, and his two friends undertook to have our two papers read before this society.

How different from this long study and preparation—this philosophic caution—this determination not to make known his fruitful conception till he could back it up by overwhelming proofs—was my own conduct. The idea came to me, as it had come to Darwin, in a sudden flash of insight: it was thought out in a few hours—was written down with such a sketch of its various applications and developments as occurred to me at the moment,—then copied on thin letter-paper and sent off to Darwin—all within one week. *I* was then (as often since) the "young man in a hurry"; *he*, the painstaking and patient student, seeking ever the full demonstration of the truth that he had discovered, rather than to achieve immediate personal fame.

Such being the actual facts of the case, I should have had no cause for complaint if the respective shares of Darwin and myself in regard to the elucidation of nature's method of organic development had been thenceforth estimated as being, roughly, proportional to the time we had each bestowed upon it when it was thus first given to the world—that is to say, as twenty years is to one week. For, he had already made it his own. If the persuasion of his friends had prevailed with him, and he had published his theory, after ten years'—fifteen years'—or even eighteen years' elaboration of it—*I* should have had no part in it whatever, and *he* would have been at once recognized, and should be ever recognized, as the sole and undisputed discoverer and patient investigator of the great law of "natural selection" in all its far-reaching consequences.

It was really a singular piece of good luck that gave to me any share whatever in the discovery. During the first half of the nineteenth century (and even earlier) many great biological thinkers and workers had been pondering over the problem and had even suggested ingenious but inadequate solutions. Some of these men were among the greatest intellects of our time, yet, till Darwin, all had failed; and it was only

Darwin's extreme desire to perfect his work that allowed me to come in, as a very bad second, in the truly Olympian race in which all philosophical biologists, from Buffon and Erasmus Darwin to Richard Owen and Robert Chambers, were more or less actively engaged.

And this brings me to the very interesting question: Why did so many of the greatest intellects fail, while Darwin and myself hit upon the solution of this problem—a solution which this celebration proves to have been (and still to be) a satisfying one to a large number of those best able to form a judgment on its merits? As I have found what seems to me a good and precise answer to this question, and one which is of some psychological interest, I will, with your permission, briefly state what it is.

On a careful consideration, we find a curious series of correspondences, both in mind and in environment, which led Darwin and myself, alone among our contemporaries, to reach identically the same theory.

First (and most important, as I believe), in early life both Darwin and myself became ardent beetle-hunters. Now there is certainly no group of organisms that so impresses the collector by the almost infinite number of its specific forms, the endless modifications of structure, shape, color and surface-markings that distinguish them from each other, and their innumerable adaptations to diverse environments. These interesting features are exhibited almost as strikingly in temperature as in tropical regions, our own comparatively limited island-fauna possessing more than 3,000 species of this one order of insects.

Again, both Darwin and myself had, what he terms "the mere passion of collecting,"—not that of studying the minutiæ of structure either internal or external. I should describe it rather as an intense interest in the mere *variety* of living things—the variety that catches the eye of the observer even among those which are very much alike, but which are soon found to differ in several distinct characters.

Now it is this superficial and almost child-like interest in the outward forms of living things, which, though often despised as unscientific, happened to be *the only one* which would lead us towards a solution of the problem of species. For nature herself distinguishes her species by just such characters—often exclusively so, always in some degree—very small changes in outline, or in the proportions of appendages, as give a quite distinct and recognizable *facies* to each, often aided by slight peculiarities in motions or habits; while in a large number of cases differences of surface-texture, of color, or in the details of the same general scheme of color-pattern or of shading, give an unmistakable individuality to closely allied species.

It is the constant search for and detection of these often unexpected differences between very similar creatures, that gives such an intellectual charm and fascination to the mere collection of these insects; and

when, as in the case of Darwin and myself, the collectors were of a speculative turn of mind, they were constantly led to think upon the "why" and the "how" of all this wonderful variety in nature—this overwhelming, and, at first sight, purposeless wealth of specific forms among the very humblest forms of life.

Then, a little later (and with both of us almost accidentally) we became travellers, collectors and observers, in some of the richest and most interesting portions of the earth; and we thus had forced upon our attention all the strange phenomena of local and geographical distribution, with the numerous problems to which they give rise. Thenceforward our interest in the great mystery of *how* species came into existence was intensified, and—again to use Darwin's expression—"haunted" us.

Finally, both Darwin and myself, at the critical period when our minds were freshly stored with a considerable body of personal observation and reflection bearing upon the problem to be solved, had our attention directed to the system of *positive checks* as expounded by Malthus in his "Principles of Population." The effect of this was analogous to that of friction upon the specially-prepared match, producing that flash of insight which led us immediately to the simple but universal law of the "survival of the fittest," as the long-sought *effective* cause of the continuous modification and adaptation of living things.

It is an unimportant detail that Darwin read this book two years *after* his return from his voyage, while I had read it *before* I went abroad, and it was a sudden recollection of its teachings that caused the solution to flash upon me. I attach much importance, however, to the large amount of solitude we both enjoyed during our travels, which, at the most impressionable period of our lives, gave us ample time for reflection on the phenomena we were daily observing.

This view, of the combination of certain mental faculties and external conditions that led Darwin and myself to an identical conception, also serves to explain why none of our precursors or contemporaries hit upon what is really so very simple a solution of the great problem. Such evolutionists as Robert Chambers, Herbert Spencer and Huxley, though of great intellect, wide knowledge, and immense power of work, had none of them the special turn of mind that makes the collector and the species-man, while they all—as well as the equally great thinker on similar lines, Sir Charles Lyell—became in early life immersed in different lines of research which engaged their chief attention.

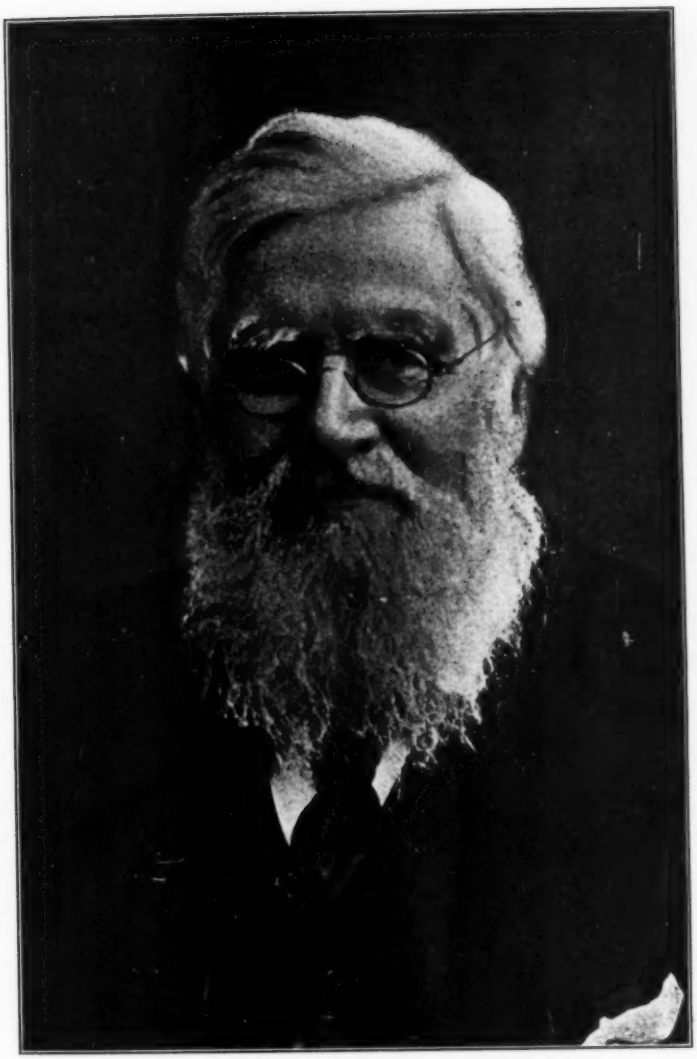
Neither did the actual precursors of Darwin in the statement of the principle—Wells, Matthews or Prichard—possess any adequate knowledge of the class of facts above referred to, or sufficient antecedent interest in the problem itself, which were both needed in order to per-

ceive the application of the principle to the mode of development of the varied forms of life.

And now, to recur to my own position, I may be allowed to make a final remark. I have long since come to see that no one deserves either praise or blame for the *ideas* that come to him, but only for the *actions* resulting therefrom. Ideas and beliefs are certainly not voluntary acts. They come to us—we hardly know *how* or *whence,* and once they have got possession of us we can not reject or change them at will. It is for the common good that the promulgation of ideas should be free—uninfluenced by either praise or blame, reward or punishment.

But the *actions* which result from our ideas may properly be so treated, because it is only by patient thought and work, that new ideas, if good and true, become adopted and utilized; while, if untrue or if not adequately presented to the world, they are rejected or forgotten.

I therefore accept the crowning honor you have conferred on me today, not for the happy chance through which I became an independent originator of the doctrine of "survival of the fittest," but, as a too liberal recognition by you of the moderate amount of time and work I have given to explain and elucidate the theory, to point out some novel applications of it, and (I hope I may add) for my attempts to extend those applications, even in directions which somewhat diverged from those accepted by my honored friend and teacher—Charles Darwin.



THE FIRST PRESENTATION OF THE THEORY OF NATURAL SELECTION[1]

By Sir JOSEPH HOOKER

I HAVE been honored by receiving from the council of our society a request that I would take up a little of your time and attention with a brief address. No theme or subject was vouchsafed to me by the council, but, having gratefully accepted the honor, I was bound to find one for myself. It soon dawned upon me that the object sought by my selection might have been that, considering the intimate terms upon which Mr. Darwin extended to me his friendship, I could from my memory contribute to the knowledge of some important event in his career. It having been intimated to me that this was in a measure true, I have selected as such an event one germane to this celebration and also engraven on my memory, namely, the considerations which determined Mr. Darwin to assent to the course which Sir Charles Lyell and I had suggested to him, that of our presenting to the society, in one communication, his own and Mr. Wallace's theories on the effect of variation and the struggle for existence on the evolution of species.[2]

You have all read Francis Darwin's fascinating work as Editor of his father's "Life and Letters," where you will find[3] a letter addressed, on June 18, 1858, to Sir Charles Lyell by Mr. Darwin, who states that he had on that day received a communication from Mr. Wallace written from the Celebes Islands requesting that it might be sent to him (Sir Charles).

In a covering letter Mr. Darwin pointed out that the enclosure contained a sketch of a theory of natural selection as depending on the struggle for existence so identical with one he himself entertained and fully described in manuscript in 1842, that he never saw a more striking coincidence: had Mr. Wallace seen his sketch he could not have made a better short abstract, even his terms standing "as heads of my chapters." He goes on to say that he would at once write to Mr. Wallace offering to send his manuscript to any journal; and concludes: So my originality is smashed, though my book (the forthcoming "Origin of Species"), if it will have any value will not be deteriorated, as all know the labor consists in the application of the theory.

[1] Reply on receiving the Darwin-Wallace medal of the Linnean Society of London on July 1, 1908.

[2] See *Jour. Linn. Soc.*, III. (1859), pp. 45–61.

[3] Vol. II., p. 116.

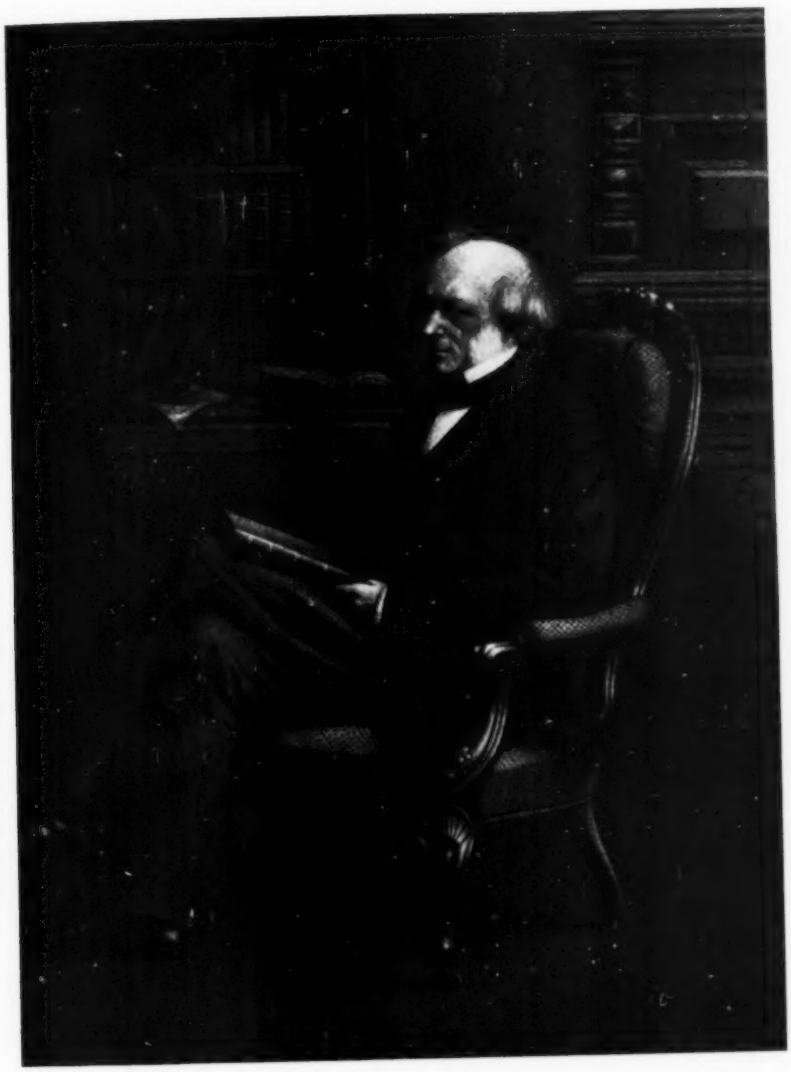
After writing to Sir Charles Lyell, Mr. Darwin informed me of Mr. Wallace's letter and its enclosure, in a similar strain, only more explicitly announcing his resolve to abandon all claim to priority for his own sketch. I could not but protest against such a course, no doubt reminding him that I had read it, and that Sir Charles knew its contents, some years before the arrival of Mr. Wallace's letter; and that our withholding our knowledge of its priority would be unjustifiable. I further suggested the simultaneous publication of the two, and offered —should he agree to such a compromise—to write to Mr. Wallace fully informing him of the motives of the course adopted.

In answer, Mr. Darwin thanked me warmly for my offer to explain all to Mr. Wallace, and in a later letter he informed me that he was disposed to look favorably on my suggested compromise, but that before making up his mind he desired a second opinion as to whether he could honorably claim priority, and that he proposed applying to Sir Charles Lyell for this. I need not say that this was a relief to me, knowing as I did what Sir Charles's answer must be.

At Vol. II., pp. 117, 118 of the "Life and Letters," Mr. Darwin's application to Sir Charles Lyell is given, dated June 26, with a postscript dated June 27. In it he requests that the answer shall be sent to me to be forwarded to himself. I have no recollection of receiving the answer, which is not to be found either in Darwin's or my own correspondence; it was no doubt satisfactory.

Further action was now left in the hands of Sir Charles and myself, we all agreeing that, whatever action was taken, the result should be offered for publication to the Linnean Society.

On June 29, Mr. Darwin wrote to me in acute distress, being himself very ill, and scarlet fever raging in his family, to which an infant son had succumbed on the previous day, and a daughter was ill with diphtheria. He acknowledged the receipt of letters from me, adding, "I can not think now of the subject, but soon will: you shall hear as soon as I can think"; and on the night of the same day he writes again, telling me that he is quite prostrated and can do nothing but send certain papers for which I had asked as essential for completing the prefatory statement to the communication to the Linnean Society of his and Wallace's "Essays." This was only forty-eight hours before the reading of the paper laid before the society by Sir Charles and myself on July 1. It may be interesting to recall that the last ordinary meeting of the session of this society is held in the middle of June. The occasion of the meeting on July 1 was exceptional, and was due to the death of the eminent botanist, Robert Brown. As a mark of respect to that great past president, the ordinary meeting of June 17 was adjourned, and a special meeting called in order to elect a successor to the vacancy on the council, caused by his decease, George



Bentham being nominated in his place. The usual election of council and officers had taken place at the anniversary meeting only a month before; and, oddly enough, for the first time among the new members of that body was Charles Darwin. Other papers were also read at the special meeting on July 1, but it will not have escaped your notice that the whole correspondence relating to the two papers on the evolution of species was subsequent to June 17; indeed, the joint letter from Sir Charles Lyell and myself communicating them to the society was only written on June 30.

Thus the death of Robert Brown was the direct cause of the theory of the origin of species being given to the world at least four months earlier than would otherwise have been the case.

The communications were read, as was the custom in those days, by the secretary of ths society. Mr. Darwin himself, owing to his own illness and distress, could not be present. Sir Charles Lyell and myself said a few words to emphasize the importance of the subject; but, as recorded in the "Life and Letters,"[1] although intense interest was excited, no discussion took place: "the subject was too novel and too ominous for the old school to enter the lists before armoring."

It can not fail to be noticed that all these inter-communications between Mr. Darwin, Sir Charles Lyell and myself were conducted by correspondence, no two of us having met in the interval between June 18 and July 1, when I met Lyell at the evening meeting of the Linnean Society; and no fourth individual had any cognizance of our proceedings.

It must also be noted that for the detailed history given above there is no documentary evidence beyond what Francis Darwin has produced in the "Life and Letters." There are no letters from Lyell relating to it not even answers to Mr. Darwin's of June 18, 25 and 26; and Sir Leonard Lyell has at my request very kindly but vainly searched his uncle's correspondence for any relating to this subject beyond the two above mentioned. There are none of my letters to either Lyell or Darwin, nor other evidence of their having existed beyond the latter's acknowledgment of the receipt of some of them; and, most surprising of all, Mr. Wallace's letter and its enclosure have disappeared. Such is my recollection of the day of the fiftieth anniversary of which we are now celebrating, and of the fortnight that immediately preceded it.

It remains for me to ask your forgiveness for intruding upon your time and attention with the half-century old, real or fancied memories of a nonogenarian as contributions to the history of the most notable event in the annals of biology that had followed the appearance in 1735 of the "Systema Naturæ" of Linnæus.

[1] Vol. II., p. 126.

THE PROGRESS OF SCIENCE

DARWIN'S MANUSCRIPT

THERE is here reproduced the text of two pages of the original manuscript of "The Descent of Man" in the handwriting of the author. This manuscript, as well as the portraits by Lock and Whitfield and by Maull and Fox reproduced above, we owe to the kindness of Mr. Charles F. Cox, president of the New York Academy of Sciences, who has permitted the use of his valuable collection of Darwiniana. With the manuscript, the handwriting of which is somewhat reduced in size, is given a transcription, and in the second column the text as it finally appeared in the first edition of the "Descent of Man" as published in 1871, Volume I., pp. 42–43.

The manuscript shows the great amount of revision which the author made in all his work. It is corrected and interlined, and when it appeared in print it had been largely again rewritten by correcting the proofs. Thus the author evidently expected this matter to appear in Chapter I., but made additions which carried it over into Chapter II. Darwin's daughter, Mrs. Litchfield, who assisted him in the correction of some of his later works, says:

"He did not write with ease, and was apt to invert his sentences both in writing and speaking, putting the qualifying clause before it was clear what it was to qualify. He corrected a great deal, and was eager to express himself as well as he possibly could."

In the "Life and Letters," Mr. Francis Darwin writes:

"Perhaps the commonest corrections needed were obscurities due to the omission of a necessary link in the reasoning, something that he had evidently omitted through familiarity with the subject. Not that there was any fault in the sequence of the thoughts, but that from familiarity with his argument he did not notice when the words failed to reproduce his thought. He also frequently put too much matter into one sentence, so that it had to be cut up into two.

"On the whole, I think the pains which my father took over the literary part of the work was very remarkable. He often laughed or grumbled at himself for the difficulty which he found in writing English, saying, for instance, that if a bad arrangement of a sentence was possible, he should be sure to adopt it. He once got much amusement and satisfaction out of the difficulty which one of his family found in writing a short circular. He had the pleasure of correcting and laughing at obscurities, involved sentences, and other defects, and thus took his revenge for all the criticism he had himself to bear with. He used to quote with astonishment Miss Martineau's advice to young authors, to write straight off and send the MS. to the printers without correction. But in some cases he acted in a somewhat similar manner. When a sentence got hopelessly involved, he would ask himself, 'Now what *do* you want to say?' and his answer written down would often disentangle the confusion."

Chpt I (11

Jealousy & something very like modesty when begging too often for food. A pet dog seems to partake of a little dog's nature. Several Persons have related that monkeys, when being laughed at, imitate the same grimaces, thus showing a tendency to Individual Reason. We always get into a passion when we catch a Dog, who keeps tooth out to him, looking at us; or go decently in the house, we say to the blood flowed.

[We with now turn to the more intellectual emotions & faculties, which are of more importance as the almost necessary steps to the development of the higher mental powers. Animals manifestly enjoy excitement, & suffer from ennui, as may be seen with dogs & cats. All animals play. Puppies with monkeys. All animals play field Wonder; & many exhibit Curiosity, sometimes proved to their cost by the hunter playing antics & then attacking them,

MANUSCRIPT OF DARWIN'S "DESCENT OF MAN"

fear & something very like modesty, when begging too often for food. Some dogs and other animals as horses easily turn sulky; some are good-tempered, others ill-tempered. A great dog scorns the snarling of a little dog. Several observers have stated that monkeys certainly hate being laughed at. They will also make for themselves imaginary offenses; thus I saw a baboon in the Zoological Gardens who always got into a furious passion, when his keeper took out a letter or book and read it aloud to him; on one occasion in his rage he bit his own leg till the blood flowed.

We will now turn to the more intellectual emotions & faculties, which are very important as the almost necessary steps to the development of the higher mental powers. Animals manifestly enjoy excitement, & suffer from ennui, as may be seen with dogs & according to Rengger with monkeys. All animals plainly feel *Wonder;* & may exhibit *Curiosity,* as is sometimes proved to their cost by the hunter playing antics and thus attracting them,

There can, I think, be no doubt that a dog feels shame, as distinct from fear, and something very like modesty when begging too often for food. A great dog scorns the snarling of a little dog, and this may be called magnanimity. Several observers have stated that monkeys certainly dislike being laughed at; and they sometimes invent imaginary offences. In the Zoological Gardens I saw a baboon who always got into a furious rage when his keeper took out a letter or book and read it aloud to him; and his rage was so violent that, as I witnessed on one occasion, he bit his own leg till the blood flowed.

We will now turn to the more intellectual emotions and faculties, which are very important, as forming the basis for the development of the higher mental powers. Animals manifestly enjoy excitement and suffer from ennui, as may be seen with dogs, and, according to Rengger, with monkeys. All animals feel *Wonder,* and may exhibit *Curiosity.* They sometimes suffer from this latter quality, as when the hunter plays antics and thus attracts them;

Ch I (72

In I has with-held with heen, & he is known to be a writer with Quality, to copy with to very Chemist & Berkeley gives a curious account of the instinctive fear of rabbits, which Li & monkeys exhibited & monkeys; but the curiosity was so great that they could not resist, it is most human perhaps, from occasionally catching their heads & lifting up the lid to lift up of the box, in which the rabbits were kept, & peeping at them. I was so much surprised at the account, that I took a well stuffed & coiled up rabbit with me to monkey House at the Zoological Gardens, & the excitement caused was one of the most curious spectacles I ever beheld. Their specimen of Cercopithecus were most alarmed; they looked about their cages & uttered sharp peculiar cries of danger, which were apparently understood by the other monkeys, a few of monkeys & one or two birds before took to action. I then placed the stuffed rabbit on the ground in one of the large compartments, & after a time the monkeys collected one at a time, forming a large circle, gazing at the

as I have witnessed with deer, & as is known to be the case with the wary chamois & with wild ducks. Brehm gives a curious account of the instinctive dread of snakes which his monkeys exhibited; but their curiosity was so great that they would not desist, in a most human fashion, from occasionally satiating their horror by lifting up the lid of the box, in which the snakes were kept, & peeping at them. I was so much surprised at this account, that I took a well stuffed & coiled up snake into the monkey House at the Zoological Gardens, & the excitement there caused was one of the most curious spectacles which I ever beheld. Three species of Cercopithecus were most alarmed; they darted about their cages & uttered sharp signal-cries of danger, which were apparently understood by the other monkeys. A few young monkeys and an old Anubis baboon took no notice. I then placed the stuffed snake on the ground in one of the large compartments, & after a time all the monkeys, staring intently, collected around it forming a large circle & presenting a most

I have witnessed this with deer, and so it is with the wary chamois, and with some kinds of wild-ducks. Brehm gives a curious account of the instinctive dread which his monkeys exhibited towards snakes; but their curiosity was so great that they could not desist from occasionally satiating their horror in a most human fashion, by lifting up the lid of the box in which the snakes were kept. I was so much surprised at his account, that I took a stuffed and coiled-up snake into the monkey house at the Zoological Gardens, and the excitement thus caused was one of the most curious spectacles I ever beheld. Three species of Cercopithecus were the most alarmed; they dashed about their cages and uttered sharp signal-cries of danger, which were understood by the other monkeys. A few young monkeys and one old Anubis baboon alone took no notice of the snake. I then placed the stuffed specimen on the ground in one of the larger compartments. After a time all the monkeys collected round it in a large circle, and staring intently, presented a most ludicrous appearance.

PORTRAITS OF DARWIN

In this number of THE POPULAR SCIENCE MONTHLY, commemorating the hundredth anniversary of Darwin's birth, are reproduced eight portraits. The first of these, given as a frontispiece, is from a Woodbury-type made from life by Lock and Whitfield and published in "Men of Mark" by Sampson, Low and Company about 1876. It gives perhaps a better impression of Darwin as he actually looked in his later years than any other portrait. There follows a portrait from a photograph by Maull and Fox taken about 1854. At the same time a similar photograph was made from which a somewhat idealized portrait was engraved in wood for *Harper's Magazine* for October, 1884. The portrait next given appeared in the *Quarterly Journal of Science* in 1866. There then follows a reproduction of an engraving on steel made for *Nature* in 1874 by C. H. Jeens from a photograph taken by O. J. Rejlander about 1870. The next illustration is a photograph of the bronze bust made by Mr. William Couper and presented by the New York Academy of Sciences to the American Museum of Natural History on the hundredth anniversary of Darwin's birth. A second photograph of this bust as it stands on the pedestal is given at the end of the number. The origin of the portrait next given is not known to the editor. The following portrait is from a photograph taken by Mrs. Cameron at the Isle of Wight in 1868. Darwin wrote under it "I like this photograph very much better than any other which has been taken of me." The last portrait is from an engraving on wood by G. Cruels for "The Life and Letters," from a photograph taken by Elliott and Fry in 1881.

There are also given portraits of several of those whose relations to Darwin and his work were especially intimate: Alfred R. Wallace, whose paper on natural selection was presented simultaneously with Darwin's and whose subsequent contributions to the theory of evolution are notable, whom Darwin calls "generous and noble"; Sir Joseph Hooker, the most eminent of British botanists, the lifelong friend and scientific adviser of Darwin, of whom he says: "I have known hardly any man more lovable"; Sir Charles Lyell, whose "Principles of Geology" was Darwin's early inspiration and who was later his warm friend and constant adviser, who with Hooker presented to the Linnean Society the papers on natural selection; the Rev. J. R. Malthus, whose "Principles of Population" suggested the idea of natural selection to both Darwin and Wallace, as Lyell's "Principles" had previously impressed on them the idea of evolution; Erasmus Darwin, poet and philosopher, defender of the doctrine of the transmutation of species, whose grandson resembled him in many traits.

ERASMUS DARWIN, M.D. F.R.S.

AUTHOR OF THE LOVES OF THE PLANTS.

CELEBRATIONS IN HONOR OF THE DARWIN CENTENARY

THE most notable celebrations of Darwin's birth and of the fiftieth anniversary of the "Origin of Species" are the exercises of the Linnean Society of London, held on July 1 of last year, and the celebrations to be held at Cambridge in June next. The Darwin-Wallace celebration of the Linnean Society was noted at the time in this journal, and a reproduction was shown of a medal struck in honor of the fiftieth anniversary of the presentation to the society of the papers on natural selection by Darwin and Wallace. These papers were reproduced in the issue of THE POPULAR SCIENCE MONTHLY for November, 1901. The celebrations at Cambridge in June will last several days, and some three hundred universities and learned societies throughout the world will be represented by delegates.

While, as is becoming, the two most elaborate commemorations of the Darwin centenary have been arranged in his own country, celebrations have been more general in the United States than in Great Britain. The most notable exercises were arranged by the American Association for the Advancement of Science and held at Baltimore on January 1. Professor E. B. Poulton, probably the most distinguished living representative of the theory of natural selection, came from England as the guest of the association to make the opening address, and this was followed by a series of papers giving an account of the state of research in the biological sciences based on the doctrine of evolution. These papers are about to be published for the association in a memorial volume by Messrs. Henry Holt and Company.

The commemorative exercises that were perhaps next in interest were held in New York City on Darwin's birthday. The New York Academy of Sciences presented to the American Museum of Natural History a heroic bust of Darwin in bronze by Mr. William Couper, illustrations of which are reproduced in this number of the MONTHLY. The addresses made on this occasion are printed above. At Columbia University, on the same day, a series of lectures on Charles Darwin and his influence on science was begun, the opening address being printed in this memorial issue.

An equally notable series of lectures on Darwin's influence is being given at Chicago, and commemorative ceremonies and addresses have been arranged not only in large centers, such as Boston and Philadelphia, but also at universities throughout the country. These include Michigan, Cornell, Missouri, Nebraska, Iowa, Iowa State College, Georgia, Brown, Wesleyan and other institutions. In some cases the celebrations extended over several days and as many as ten or more papers and addresses were given.